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Simulation Model of Change Orders and their Impact on Building Projects Performance in Gaza Strip

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بسم الله الرحمن الرحيم

" يرفع الله الذين امنوا منكم و الذين أوتوا العلم

درجات و الله بما تعملون خبير"

صدق الله العظيم

[سورة المجادلة :11]

Dedication

To Allah's most sacred religion 'Islam", which urged us to seek knowledge on its first revelation

To our homeland Palestine, which embraced and took care of us

To my father's soul, who in his life, spared no effort to help me pursue my education.

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ABSTRACT

The main character of the construction projects is complexity where many human and non-human factors and variables play essential roles. So, when change orders occur all projects performance strongly affected. A recent survey of professional engineers identified changes as the major cause of project failure and Gaza Strip is not exception where the main cause of delay, over budgeting, and productivity losing in Gaza Strip are due to change orders.

This research discusses the change orders and their impact on projects performance in the Gaza Strip using a combination of interviews and 15 case studies. These studies encompassed 6 educational building projects, one of which was rehabilitation, 4 health building projects, two of which were rehabilitation, and, 5 residential building projects carried out in the Gaza Strip. These projects were investigated to collect the data required for in-depth study and analysis. The projects documented and analyzed were between 1996 and 2005.

From the case studies and interviews, factors influencing the number of change orders in the Gaza strip were determined and then the impact of change orders on cost, time, and productivity for each factor was also determined for the 15 case studies. The factors were ranked according to their occurrences and impact on projects performance to find the most important factors.

A simulation model was built to model change orders occurrences and their impact on cost, time, and productivity for building projects in the Gaza Strip. Verification of the model was checked and was given 97% accuracy in forecasting increase in cost, 99% accuracy in forecasting decrease in cost, and 96% accuracy in forecasting time extension. The validity of the model was also checked firstly by interviews and then by examining a random case, where it gave 97% accuracy in forecasting increase in cost, and 98% in forecasting extension on time, which means that the simulation model can forecast the impact of change orders on project performance in the Gaza strip.

ملخص الدراسة

من أبرز السمات المميزة للمشاريع الهندسية تعقيدها وتشابكها، حيث أن هناك العديد من العوامل البشرية و غير البشرية والعديد من المتغيرات التي تلعب دورا هاما فيها. لذا عند حدوث الأوامر التغييرية يتأثر أداء المشاريع بشكل كبير. من أجل ذلك عرف بعض المهندسين المتخصصين التغييرات على أنها السبب الرئيسي في فشل المشاريع الهندسية. قطاع غزة لا يشذ عن هذا التعريف حيث أن الأوامر التغييرية هي السبب الرئيسي للتأخير أو زيادة تكلفة المشروع أو فقد الإنتاجية.

لقد تناول هذا البحث مناقشة الأوامر التغييرية الحادثة في مشاريع البناء وتأثيرها على أداء المشاريع في قطاع غزة. استخدم هذا البحث أدوات المقابلات العلمية ودراسات الحالة، فكان فيه 15 دراسة حالة مكونة من 6 مشاريع لبناء مدارس أحدها كان إعادة تأهيل، كما كان هناك 4 مشاريع بناء مباني تابعة لوزارة الصحة الفلسطينية كان اثنان منهما إعادة تأهيل، كما واحتوت دراسات الحالة على 5 مشاريع سكنية. تراوح زمن إنشاء هذه المشاريع بين 1996 و 2005.

بعد إتمام المقابلات ودراسات الحالة، جمعت الأوامر التغييرية الحادثة في ال 15 مشروع هندسي، حيث جمع كل أمر تغييري ثم جمع تأثيره على التكلفة وزيادة مدة المشروع والإنتاجية ثم بعد ذلك رتبت العوامل المسببة للأوامر التغيرية طبقا لأكثرها تسببا، تلى ذلك ترتيبها مرة أخرى طبقا لأشدها تأثيرا على أداء المشاريع الهندسية، بعد ذلك تمت دراسة هذه العوامل بعناية لإيجاد سبل التعامل معها.

بعد تجهيز العوامل المسببة للأوامر التغييرية وتأثيرها تم بناء نموذج محاكاة لمحاكاة حدوث الأوامر التغيرية وتأثيرها على التكلفة والوقت والإنتاجية لمشاريع البناء في قطاع غزة. بعد ذلك تم التحقق من نتائج هذا النموذج حيث أعطى دقة قدرها 97% في توقع الزيادة على التكلفة، كما وأعطى دقة قدرها 99% في توقع خفض الأوامر التغيرية للكلفة، كذلك أعطى دقة قدرها 96% في توقع زيادة الأوامر التغييرية لزمن المشاريع الهندسية. بعد ذلك تمت التحقق من صلاحية هذا النموذج المحاكي بطريقتين أولهما المقابلات، والطريقة الثانية كانت بتطبيقه على مشروع أخر فأعطى دقة مقدارها 97% في توقع الزيادة في التكلفة، ودقة مقدارها 98% في توقع زيادة المدة الزمنية للمشروع، مما يجعل من الممكن القول أنه قد توفرت أداة في غزة لتوقع تأثير الأوامر التغيرية على التكلفة والزمن والإنتاجية للمشاريع الهندسية.

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Chapter 1

Introduction

Change affects every aspect of human endeavors, and construction is not an exception. A recent survey of professional engineers identified change as the major cause of project failure (Hallock, 2006). As a result of making some interviews in Gaza Strip, change orders play a significant role in construction because they have a great impact on cost, schedule, quality, safety, and productivity. So, they are one of the major causes of project failure.

The concept of changes in Gaza is unclear, so project parties deal with their construction management problems as reactants without depending on any deep scientific concept. Because of that, this research intends to provide project parties in Gaza Strip with an effective change orders management tool. This tool is a simulation model which explains to contractors how change orders occur and how such orders impact performance.

This research will contribute to the creation of a tool in forecasting the impact of change orders on projects' performance.

1.1 Background

There are no in-depth studies conducted in the Gaza Strip to discuss change orders and their impact on performance. However, change orders may be found as minor factors in some studies, for example change orders take (relative importance index) RII equal 0.65 in their impact on time and cost over runs on construction projects in the Gaza Strip (Al-Najar, 2008). In affecting the performance of construction project the RII was equal 0.65 (Abo-Shaban, 2008).

1.1.1 Change order definition

A change order is an action that specifies and justifies a change of the scope of a construction contract that alters the original time of completion or the project total

cost, or both (cited by Mokbel, 2003). It is also defined as a change is any modification to the contractual guidance provided to the contractor by the owner, owner's agent or design engineer (Mokbel, 2003).

1.1.2 Types of change orders

Change orders have four main types. Those types are actual, constructive, cardinal, and conditional (Hunt, 2005). According to CSU (2000) the types of change orders are normal change orders, and emergency change orders.

1.1.3 Major factors influencing the occurrences of changes

The group of major factors influencing the number of changes are as follows (Boot, 2005; Hallock, 2006):

i. Design errors
ii. Changes in market conditions
iii. Scope and quantities of work
iv. External conditions
v. Differing site conditions
vi. Suggestion to initiate better
vii. Changes in design preference
viii. Contract conditions
ix. Actions by others
x. final coordination

1.1.4 Impact of change orders

There are numerous effects brought about by changes and change order in construction. In this section, the researcher examines some of the effects commonly encountered. According to Arain and Pheng (2005), change orders have a potential effect on the cost, time, productivity, quality, health and safety, hiring new professionals, delay in payment, rework and demolition, tarnish a firm's reputation, poor professional relations and disputes among professionals.

1.1.5 Controls

The parties responsible for change orders are the following:

1. Owner

The owner can cause damaging impact through failure to understand scope objectives and program for the project. Too many changes can cause disruption to the project coordination and construction sequencing (Atkins and Simpson, 2006).

2. Contractor

One of the most damaging impacts on a project is contractor installation of nonconforming work that the owner accepts to save remediation time or avoid forced correction efforts (Atkins and Simpson, 2006).

3. Architect

The architect can cause disruption and damaging impact through excessive errors and omissions that can occur when construction documents are poorly prepared and coordinated (Atkins and Simpson, 2006).

Therefore, the control must be in the design sage, construction stage, and design-construction interface stage (Arain and Pheng , 2005).

1.1.6 Theoretical model for change orders

Arain and Pheng (2006a) built a good model for change management system (CMS). The model consists of six fundamental stages linked to two main components, a knowledge-base and a controls selection shell for making more informed decisions for effective management of variation orders. The database was developed through the collection of data from source documents of past projects, questionnaire survey, literature review, and in-depth interview sessions with the professionals who were involved in the projects. The knowledge-base was developed through initial sieving and organization of data from the database.

1.2 Research Outline

This research comprises seven chapters. Chapter One is an introduction explaining the importance of this research study and its objectives. Chapter Two contains the change orders review of literature. Chapter Three highlights the survey work. It also defines the causes, effects, and the controls as they are used in the survey. Chapter Four illustrates the research methodology employed for dealing with the cases. Chapter Five pinpoints the results and findings of the study. Chapter Six

pinpoints the results and findings of the model. Chapter Seven presents the study conclusions and recommendations.

1.3 Statement of the Problem

A change order is a written order to the contractor, signed by the owner, and issued after the execution of the contract, authorizing a change in the work or an adjustment in the contract sum or time (Hallock, 2006). Changes in drawings and contract documents usually lead to change in the contract price and/or schedule. Changes also increase the possibility of contractual disputes. In general, changes present problems to all parties involved in the construction process. Changes are the major cause of project failure (Hallock, 2006). From some interviews which was done with some construction managers in Gaza Strip, change orders were the main cause of increasing in contract value and/or the extension of time.

1.4 Aim

The aim of the thesis is not only to determine the major factors causing changes and their impacts on performance, but also building a simulation model for predicting their impacts.

1.5 Objectives

The main objectives of the study are:

1- Determining the major factors influencing change orders in the building projects in Gaza Strip.
2- Determining the impacts of change orders on cost, schedule, and productivity.
3- Building a simulation model to measure the impact of change orders on time, cost, and productivity for building projects in the Gaza Strip.

1.6 Key Questions

What are the major factors influencing the number of change orders? Is there a significant impact of those factors on performance? Is it possible to build a simulation model of change orders and their impact on performance? How can contractors, consultants, and owners benefit from the results of the research?

1.7 Methodology

The methodology used in conducting this research includes the following:

1- Literature review.
2- Interviews.
3- Case studies.
4- Analysis.
5- Building a simulation model.
6- Conclusion, recommendations, and further studies**.**

Following is a detailed description of the research methodology.

1.7.1 Literature review

Developing a better understanding of the research objectives, a comprehensive literature review was done to achieve the following:

1- Determining the definition, types, and actions related to change orders.
2- Identifying the major factors influencing the occurrences of change orders in the Gaza Strip.
3- Identifying the impact of changes on time and the methods used to measure delay factors.
4- Identifying the impact of changes on productivity and the methods employed to measure productivity losses during changes.
5- Identifying the impact of changes on cost and the methods utilized to measure the cost variation.

1.7.2 Interviews

An interview approach encompassing three main phases was carried out in the Gaza Strip aimed at collecting the required information for in-depth study and analysis.

1.7.3 Case studies

Case studies are the main tool in this research. Fifteen building projects were taken as case studies and the following tasks were conducted:

1- Collecting the contract documents, monthly reports, weekly reports, daily logs, and other project documents.

2- Communicating with each project manager, owner, and contractor to collect the project history.
3- Determining the major factors influencing the occurrences of each change.
4- Determining the impact of each change on performance from projects documents and interviews.

1.7.4 Analysis

The data was analyzed as follows:

1- Statistical analysis was used to analyze the data to rank the factors according to their importance and impacts.
2- By calculating the frequency of % occurrences, the weight of each factor causing occurrences of changes was found and the factors were ranked according to their occurrences. Afterward, the mean of impact of each factor was calculated and the factors were re-ranked according to their impact.
3- The probability distribution of the factors and their impact were calculated to build the simulation model using Arena (Cor, 1998).

1.7.5 Model building

The data collected through the case studies was used to build the simulation model. Then, the impact of changes on cost, schedule, and productivity would appear when users input the changes. A simple flow chart for building the model is shown in Figure 1.1.

1.7.6 Conclusion, recommendations, and further studies

Finally, the fulfillment of the objectives of this research was tested, and some recommendations were derived.

The problems were discussed and consequently further studies were suggested.

1.8 Scope and Limitations

The study was limited to building construction projects (i.e. projects costing over 0.2 million dollars in the Gaza Strip executed by building contractors Grade 1 and 2 as classified by the Contractors Union in Gaza Strip).

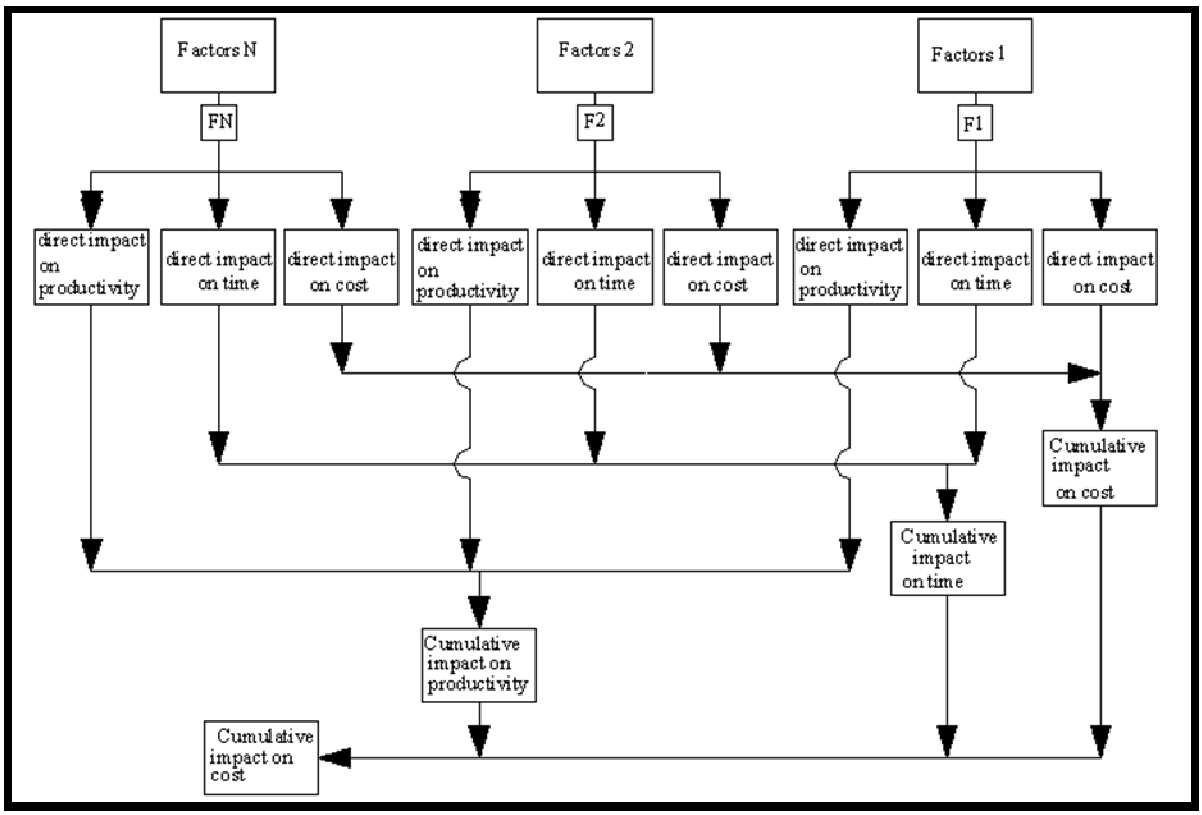


Figure 1.1: Flow chart of the simulation model

Chapter 2

Literature Review

Change orders take a middle rank in their impact on time and cost over runs on construction projects in Gaza strip (Al-Najar, 2008). Also they take a middle rank in affecting the performance of construction projects (Abo-Shaban, 2008).

2.1 Change Order Definition

Webster's dictionary defines “change” in the construction industry as transformation or modification, a variation or deviation, the substitution of one thing for another, and a replacement or substitution (Galloway, 2007).

In construction, change order is defined as "an action that specifies and justifies a change to the scope of a construction contract that alters the original time of completion or the project total cost, or both" (Mokbel, 2003).

A change is any modification to the contractual guidance provided to the contractor by the owner, owner’s agent, or design engineer (CII, 2000).

Any event, which results in a modification of the original scope, execution time or cost of work (Lee, 2001)**.**

Change means movement, and movement means friction. Only in the frictionless vacuum of a nonexistent abstract world can movement or change occur without that abrasive friction of conflict **(**Hallock, 2006).

A Change Order is a written instrument prepared by the Architect and signed by the Owner, Contractor and Architect (Libor et al, 2003).

The impact of multiple changes is define as large, untimely, and numerous change orders have a bad effect on productivity (Galloway, 2007). According to CII (2000), the problems exacerbated when multiple changes are introduced into the project.

Change orders have four main types. Those types are actual, constructive, cardinal, and conditional. According to CSU (2007), the types of change orders are

normal change orders, and emergency change orders.

Actual change: An actual change arises in those circumstances where the owner directs a change to the scope of work (Hunt, 2005).

Constructive change: A constructive change occurs when the owner, by his action and/or inaction, changes the scope of work, but does not recognize it as a change (Hunt, 2005).

Cardinal change: A cardinal change has long been recognized in the federal sector of contracting (Hunt, 2005). Also, it is a change or series of changes that are beyond the scope of the contract (Libor et al, 2003; Guerrant, 1997).

2.2 The Legal Aspects

No one can deny that change orders have a great impact on the performance of projects; therefore, most contracts contain specific clauses that indicate who is authorized to take these decisions. In many construction contracts, the engineer has the authority to order or approve changes to the works as specified in the contract (International Labour Organization, 2006). On the other hand, change orders in some contracts are used when the Owner and Contractor agree on the price and the change in schedule (ECAT, 2003).

The worst impacts of change orders are on cost, schedule, and productivity, where this impact comes from the parties which have the responsibility. These parties may cause damaging impact as follows:

1 The owner can cause bad impact through failure to understand scope objectives and program for the project. The repeated numbers of changes can cause disruption to the project coordination and construction sequencing (Atkins and Simpson, 2006).
2 Contractor installation of nonconforming work is one of the worst impacts on a project. The owner accepts to save remediation time or avoid forced correction efforts (Atkins and Simpson, 2006).
3 The architect can cause disruption and bad impact through errors, omissions, and other factors in design errors group. That can occur when construction documents are poorly prepared and coordinated (Atkins and Simpson, 2006).

2.3 Major Factors Influencing the Occurrences of Change Orders

Factors causing change orders in many other countries were collected from many previous studies. Table 2.1 shows the major factors influencing the occurrences of change orders.

Table 2.1: Major factors influencing the occurrences of change orders

#	Group	Factors	References
1	**Design errors**	Errors.	(County, 2005; Libor et al, 2003; WSDOT, 2007; Hallock, 2006; Cor, 1998).
		Omissions.	(Libor et al, 2003; WSDOT, 2007; Arain and Pheng, 2005; Hallock, 2006; Cor, 1998).
		Ambiguities.	(Hunt, 2005).
		Inconsistencies.	(Hunt, 2005).
		Impossibilities.	(Hunt, 2005).
		Change in design request.	(County, 2005).
		Design criteria changes.	(WSDOT, 2007).
		Inadequate design.	(Arain, 2005).
		Change in design by consultant.	(Arain, 2005; Arain and Pheng, 2005).
		Design complexity.	(Arain and Pheng, 2005).
		Inadequate working drawing details.	(Arain and Pheng, 2005).
		Inadequate shop drawing details.	(Arain and Pheng, 2005).
		Consultant's lack of required data.	(Arain and Pheng, 2005).
		Noncompliance of design with owner's requirements.	(Arain and Pheng, 2005).
		Change in specifications by consultant.	(Arain and Pheng, 2005).
		Lack of contractor's involvement in design.	(Arain and Pheng, 2005).

Table 2.1: Major factors influencing the occurrences of change orders (contd.)

#	Group	Factors	References
2	**Changes in market conditions**	Specified item became unavailable.	(Hunt, 2005).
		New products became available, cheaper, more efficient.	(Hunt, 2005).
		Substitution of materials or procedures.	(Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).
3	**Scope and quantities of work**	Significant changes in the quantities of work.	(Ohio Department of Transportation, 1998).
		Significant alteration of the work.	(Ohio Department of Transportation, 1998).
		Method of construction:	(Ohio Department of Transportation, 1998).
		Final measurements / calculations.	(Ohio Department of Transportation, 1998).
		Quantity changes to meet field conditions.	(Ohio Department of Transportation, 1998).
		Plan errors.	(Ohio Department of Transportation, 1998).
		Materials plan errors.	(Ohio Department of Transportation, 1998; WSDOT, 2007).
		Change of plans or scope by owner.	(Arain, 2005; Arain and Pheng, 2005).
		Change in specifications by owner.	(Arain, 2005; Arain and Pheng, 2005).
		Change in the owner's requirements (changes in scope).	(Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).
		Owner, architect or contractor, contractor desire to improve his financial conditions.	(Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

Table 2.1: Major factors influencing the occurrences of change orders (contd.)

#	Group	Factors	References
3	**Scope and quantities of work**	Contractor financial difficulties.	(Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).
		Additional or modified scope of work.	
		Change of schedule by owner.	(Libor et al, 2003).
		Inadequate project objectives.	(Arain and Pheng, 2005).
		Impediment in prompt decision making process.	(Arain and Pheng, 2005).
		Obstinate nature of owner.	(Arain and Pheng, 2005).
		Change in work sequence.	(Arain and Pheng, 2005).
			(Cor, 1998).
4	**External conditions**	Uncovering disclosed existing conditions.	(Hunt, 2005).
		uncovering unknown existing conditions.	(Hunt, 2005).
		Strikes.	(George, 1982).
		Extreme weather condition.	(George, 1982).
		Material non- availability.	(George, 1982).
		Unforeseen site condition.	(George, 1982).
		Presence of field conditions not described in the bid.	(County, 2005).
5	**Differing Site Conditions**	Differing site conditions.	(Arain and Pheng, 2005).
		Safety considerations.	(Arain and Pheng, 2005).
		Differing subsurface conditions.	(Ohio Department of Transportation, 1998).
		Differ from conditions represented in the bid documents.	(Libor et al, 2003).
6	**Suggestion to initiate better**	Suggestions to initiate faster.	(Hunt, 2005).
		Suggestions to initiate more economical construction.	(Hunt, 2005).

Table 2.1: Major factors influencing the occurrences of change orders (contd.)

#	Group	Factors	References
6	**Suggestion to initiate better**	Value engineering.	(Al-Dubaisi, 2000), (Al-Jishi and Al-Marzoug, 2008; Mokbel, 2003).
7	**Changes in design preference**	Nonperformance of a team member.	(Boot, 2005).
		Delays in the project.	(Boot, 2005).
		Defective workmanship.	(Arain and Pheng, 2005).
		Unavailability of skills.	(Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008; Arain and Pheng, 2005).
		Unavailability of equipment.	(Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008; Arain and Pheng, 2005).
		Poor procurement process.	(Arain and Pheng, 2005).
		Long lead procurement.	(Arain and Pheng, 2005).
8	**Contract conditions**	Contract conditions.	(Boot, 2005).
		Size of project.	(George, 1982).
		Magnitude of facility.	(George, 1982).
		Type of construction (new – renovation).	(George, 1982).
		Previous similar projects between owners and contractor.	(George, 1982).
		Type of contract.	(George, 1982).
		Owner project's budget.	(George, 1982).
		Consultant’s lack of judgment and experience.	(Arain and Pheng, 2005).
		Lack of consultant’s knowledge of available materials.	(Arain and Pheng, 2005).
		Honest wrong beliefs of consultant.	(Arain and Pheng, 2005).

Table 2.1: Major factors influencing the occurrences of change orders (contd.)

#	Group	Factors	References
8	**Contract conditions**	Honest wrong beliefs of contractor.	(Arain and Pheng, 2005).
		Equipment obstinate nature of consultant.	(Arain and Pheng, 2005).
		Materially unbalanced Bid.	(Manzo, 1998).
		Mathematically unbalanced Bid.	(Manzo, 1998).
		Contractor's desired profitability.	(Arain and Pheng, 2005).
		Contractor's obstinate nature.	(Arain and Pheng, 2005).
		Lack of a specialized construction manager.	(Arain and Pheng, 2005).
		Fast track construction.	(Arain and Pheng, 2005).
		Contractor's lack of judgment and experience.	(Arain and Pheng, 2005).
		Lack of strategic.	(Arain and Pheng, 2005).
		Contractor's lack of required data.	(Arain and Pheng, 2005).
9	**Actions by others**	Utility companies.	(Ohio Department of Transportation, 1998; Libor et al, 2001).
		Regulatory agencies.	(Ohio Department of Transportation, 1998; Libor and Lewis, 2003).
		Local governments.	(Ohio Department of Transportation, 1998; Libor and Lewis, 2003).
		Allowed mark-up.	(QAR, 1998).
		A prevalent practice on this project and/or district.	(QAR, 1998).
		Emergency.	(QAR, 1998).
		Building codes/inspector.	(Hunt, 2005).

Table 2.1: Major factors influencing the occurrences of change orders (contd.)

#	Group	Factors	References
9	**Actions by others**	User needs. Review of the project by the proper governmental agency. Addition of new work or deletion of work. Acceleration. Suspension of work. Change in economic conditions. Socio-cultural factors..	(Hunt, 2005). (Boot, 2005). (Ohio Department of Transportation, 1998). (Ohio Department of Transportation, 1998). (Ohio Department of Transportation, 1998). (Arain and Pheng, 2005). (Arain and Pheng, 2005).
10	**final coordination**	Scope. Mechanical and electrical provision. Lack of coordination: Technology changes.	(Arain and Pheng, 2005). (Arain and Pheng, 2005). (Arain and Pheng, 2005). (Arain and Pheng, 2005; Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

2.4 Impact of Change Orders

Change orders have numerous effects on construction industry. In the following sections, some of these effects which are commonly encountered were examined.

2.4.1 Impact of changes on cost

Change orders have an impact on cost, whose direct changes can be easily calculated. However, items such as home-office overhead, increased labor costs, equipment and material costs, financing costs, and overhead, are not easily quantifiable (Abdul-Malak et al, 2002).

The change in cost was defined as the difference between the cost at the end of the project and the original budget as reflected in (Equation 2.1) (Ibbs et al, 2003).

$$\text{Change in cost (\%)} = \frac{\text{final cost} - \text{original budget}}{\text{original budget}} \times 100 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots eq\ 2.1$$

Serag and Oloufa (2007) built a model to calculate the impact of changes on cost based on (Equation 2.2) and concluded that only 57% of the changes of the response variable increase the contract price.

$$\%\ \text{inc. due to change} = \frac{\text{cumulative cost of the change order to date(\$)} \times 100}{\text{original cost of the project (\$)}} \ldots \text{eq } 2.2$$

The increases in cost resulting from any major additions or alterations in the design which may eventually increase the project cost. In every construction project, a contingency sum is usually allocated to cater for possible changes in the project, while keeping the overall project cost intact (Arain and Pheng, 2005).

2.4.2 Impact of changes on time

Completion schedule delay is a frequent result of variations in construction projects (Arain and Pheng, 2005). It can be defined as the difference between the time used to complete the whole project and the estimated time to complete the project where (Equation 2.3) shows that (Ibbs et al, 2003).

$$\text{Change in schedule (\%)} = \frac{\text{total time used} - \text{original estimated time}}{\text{original estimated time}} \times 100 \ldots\ldots eq\ 2.3$$

Logistic delays may occur due to changes that require new materials and equipment. Arain and Pheng (2005) observed that logistic delays have significant effects on changes in construction projects.

Frequent procurement delay may occur in the project due to changes that require new materials and specialized equipment (Arain and Pheng, 2005; Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

CPM analysis is a useful method in identifying whether the time needed to finish an activity has affects on finishing time or not, attributing each part to the party responsible for it, and studying the overall impacts on the project schedule. There are three established delay analysis techniques (viz. the ‘what-if technique’, the ‘but-for technique’, and the ‘time impact analysis (Abdul-Malak et al, 2002).

2.4.3 Impact of change orders on labor productivity

Productivity loss was studied by evaluating causes and effects specific to a

particular project and, when possible, performing differential analyses between normal and impacted periods of the work. Industry studies alone are of limited use (McEniry, 2007). Interruption, delays, and redirection of work during change orders have a negative impact on labor productivity (Arain and Pheng 2005; Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

Cumulative impact on productivity is not just a theoretical concept but also a real occurrence on construction projects suffering numerous changes, the impact of which is difficult to recognize even if all the individual changes are recognized and priced (Ibbs, 2007).

The first trial to measure the productivity losses during change orders was conducted by Leonard (1987), who established the relationship between change orders and the productivity loss illustrated in Figure2.1 below.

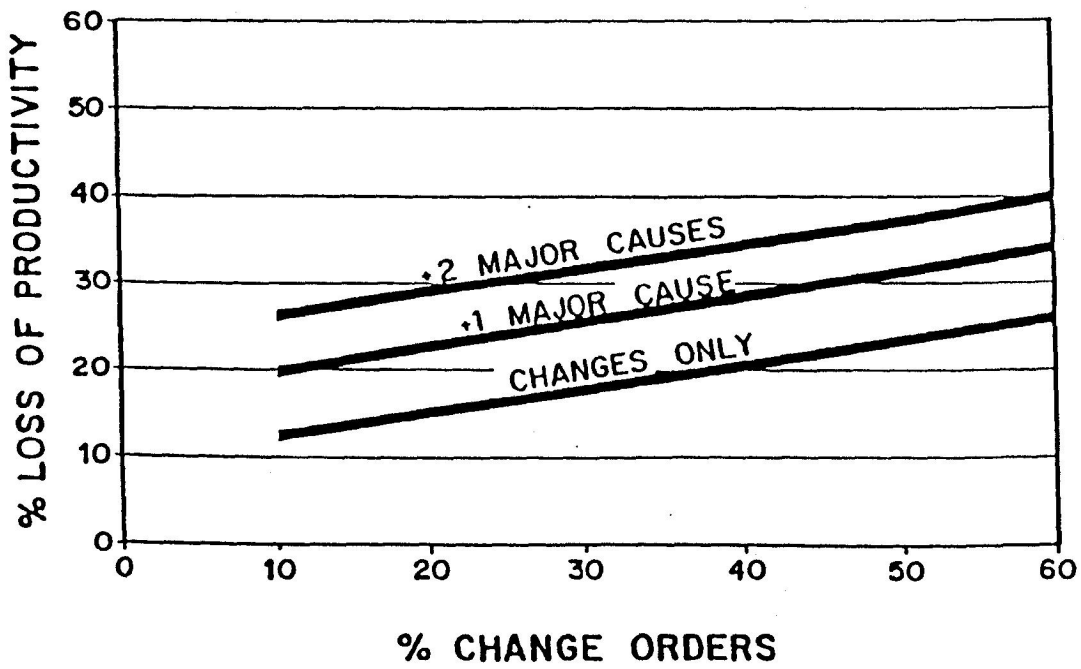


Figure 2.1: Relationship between change orders and productivity loss (Leonard, 1987)

Many industry professionals believe that changes implemented late in a project cause a greater loss of labor efficiency (Hanna, 1999).

Hanna et al (2002) calculated the expected loss in labor productivity by using the statistical fuzzy approach given by (Equation 2.4).

$$y* = \frac{\sum y \times A(y)}{\sum A(y)} = 7.2\% \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eq\ 2.4$$

Measuring productivity losses in construction industry has different ways according to Abdul-Malak et al (2002), who have cited six methods. These methods are: the total cost method, the modified total cost method, the factor-based methods, the baseline method, the modified baseline method and interesting methodology to estimate disruption effects. These methods are all used to measure total productivity losses.

The above six methods are to measure the cumulative impact of change orders but to provide a quantitative method for both owners and contractors to determine if change has impacted a project. CII (2000) generated a linear regression equation to predict the magnitude of impact of change orders on labor productivity. The linear regression given by (Equation 2.5) is used to predict the magnitude of impact of change orders on labor productivity (% productivity loss).

$$\%\text{Delta} = 0.37 + 0.12\,\text{Percent Change} - 0.08\,\text{PM \% Time On Project} - 0.17\,\%\,\text{OwnerInitiatedCO} - 0.09\,\text{Productivity} - 0.05\,\text{Overmanning} + 0.02\,\text{Processing Time} \ldots\ldots eq\ 2.5$$

The definition of each of the independent factors listed in the above equation is given in (Table 2.2).

A good distribution between changes and productivity (Figure 2.2 and 2.3) and a formula to determine productivity loss during changes was generated by Ibbs (2003), this formula is as follows:

$$= \frac{(\text{PROD Unimpacted})(\text{W} - \text{HR Uni mpacted}) + (\text{PROD Impacted})(\text{W} - \text{HR Impacted})}{\text{W} - \text{HR Unimpacted} + \text{W} - \text{HR Impacted}}$$

Where,

$\text{PROD}_{\text{Unimpacted}}$ = Productivity for an un impacted project period.

$\text{PROD}_{\text{Impacted}}$ = Productivity for an impacted project period.

$\text{W-HR}_{\text{Unimpacted}}$ = Number of Work-Hours for an unimpacted project period.

$\text{W-HR}_{\text{Impacted}}$ = Number of Work-Hours in an impacted project period.

Ibbs et al, (2007) built an impact of changes model to deal with productivity loss due to change orders. Figure 2.4 shows that.

The main factors of productivity loss during changes are: Intensity (Number of change orders - their frequency - ratio of change orders hours to contract hours), timing in relation, work type, type of impact, project phase, and on-site management (Moselhi et al, 2005).

2.4.4 Quality degradation

The quality of work was usually poor because of frequent changes which contractors tended to compensate for the losses (CII, 1995; Ndihokubwayo and Haupt, 2007).

Table 2.2: Equation 2.5 factors definition (CII, 2000)

Factor	**Definition**	**Limits**
Percentage change	Percentage of change on project in terms of original budgeted work hours	2.5% to 90%
PM% Time on project	Percentage of time the project manager spends on the project.	0% to 100%
%OwnerIntiatedCO	Percentage of change orders initiated by the owner	0% to 100%
Productivity	Did you track productivity for the project? (input[work hours] output[units installed]. The contractor could use one of the following: Track % complete by earned value. Track % complete by actual earned work-hours. Track % complete by actual installed quantities	0 = NO 1 = Yes
Overmanning	Did overmanning occur on the project? [Estimated peak manpower Actual man power] < 0.77	0 = NO 1 = Yes
Processing time	The period of time between initiation of the change order and the owner's approval of the change order: 1-7 days = 1, 8-14days = 2, 15-21 days = 3 22-28 days = 4, >28 days = 5	1 to 5

2.4.5 Health and safety

The occurrence of change orders may affect health and safety conditions. This is because change in construction methods, materials and equipment may require additional health and safety measures (Ndihokubwayo and Haupt, 2007).

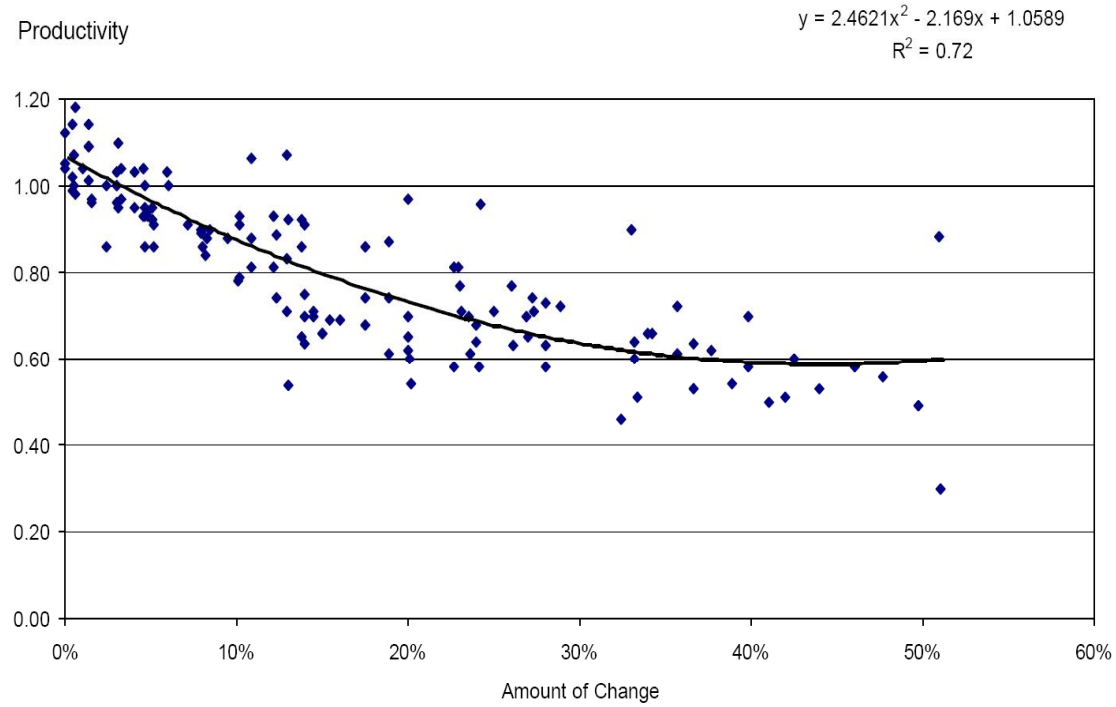


Figure 2.2: Construction productivity vs. project change (Ibbs, 2003)

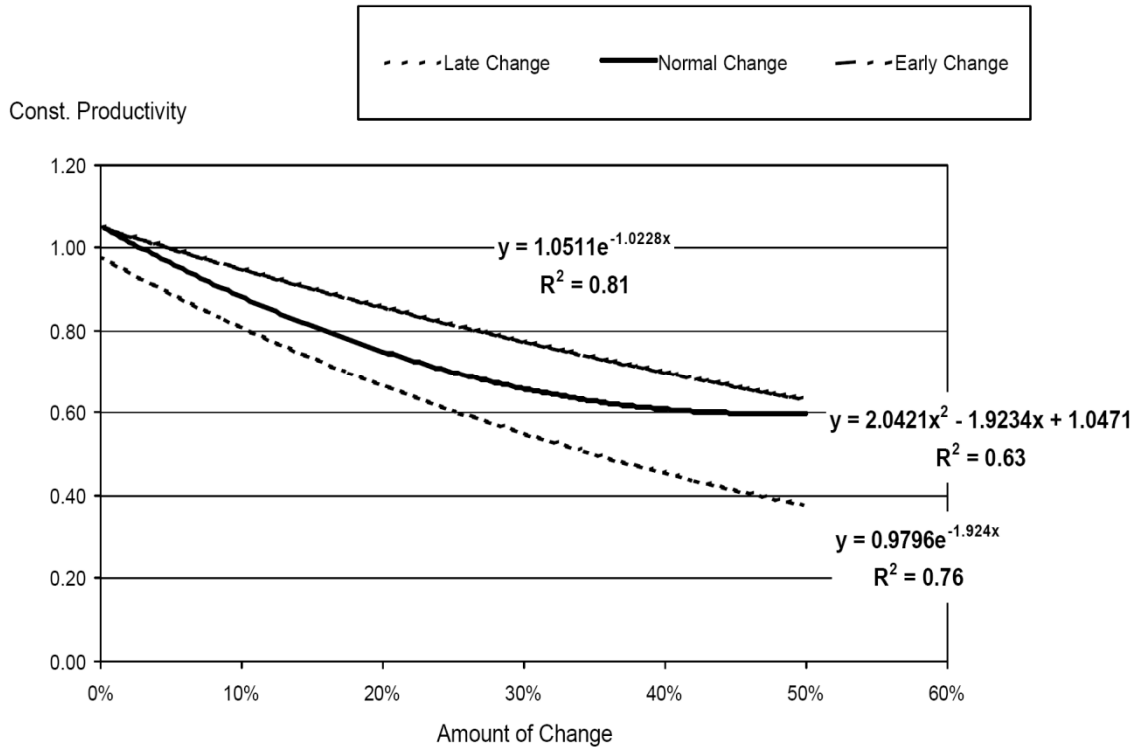


Figure 2.3: Construction productivity vs. timing of change (Ibbs, 2003)

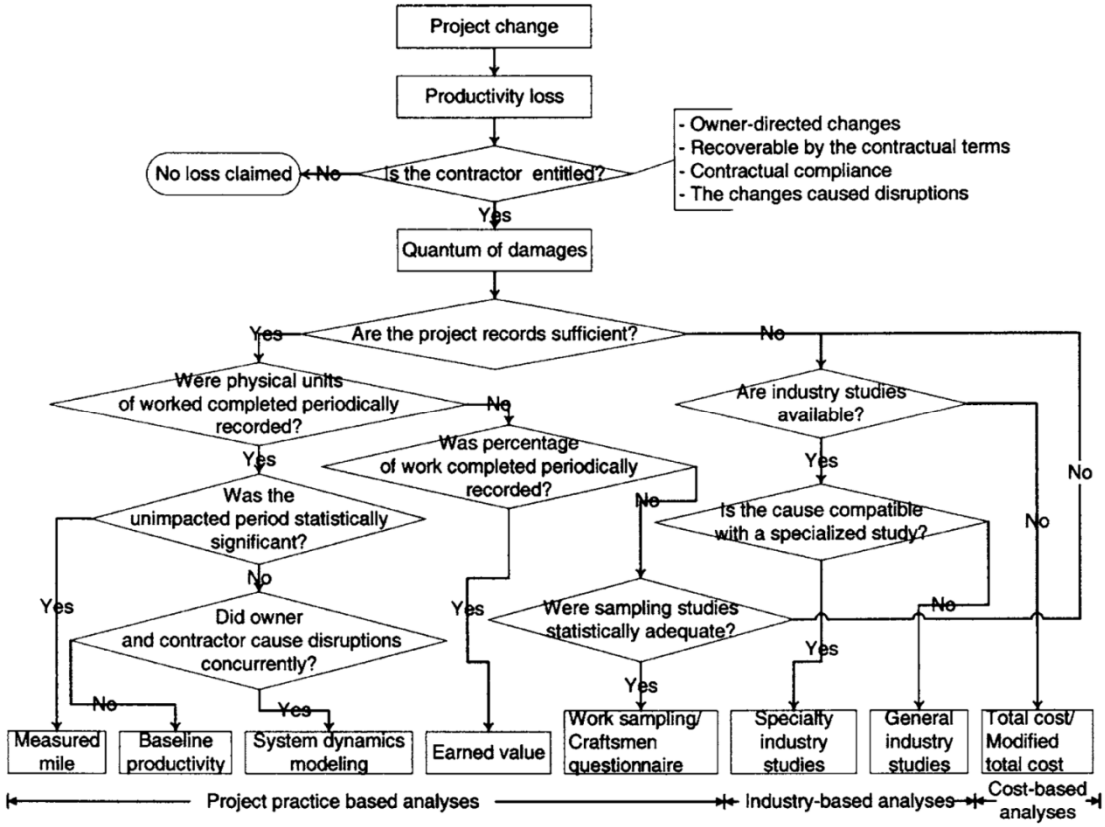


Figure 2.4: Impact of changes model (Ibbs et al, 2007)

2.4.6 Hiring new professionals

A new specialized manpower may be needed to do the change orders especially in the complex technological projects (CII, 1995).

2.4.7 Delay in payment

Delay in payment occurred frequently due to changes in construction projects (CII, 1990). Changes may hinder the project progress, leading to delays in achieving the targeted milestones during construction (CII, 1995), which leads to delay in the payment to the contractors (Arain and Pheng, 2005).

2.4.8 Rework

Changes which are imposed when construction is underway or even completed usually lead to reworks (CII, 1990). Rework and demolition are potential effects of changes in construction, depending on the timing of the occurrence of the changes. These effects are to be expected due to changes during the construction phase (Arain and Pheng, 2005; Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

2.4.9 Tarnish firm's reputation

Changes are referred to as a major source of construction claims and disputes. The claims and disputes may affect the firm's reputation adversely, leading to insolvency in severe cases. Changes also increase the possibility of professional disputes. Conventionally, changes present problems to all the parties involved in the construction process (Arain and Pheng, 2005).

2.4.10 Poor professional relations

Change orders may affect professional relations, leading to disputes which must be resolved firstly through negotiation; then they may be resolved by litigation (Arain and Pheng, 2005).

2.4.11 Disputes among professionals

Like poor professional relations, disputes among professionals are also potential effects of frequent changes in construction projects. Disputes over change orders and claims are inevitable and the change clauses are often the source of project disputes (Arain and Pheng, 2005; Al-Dubaisi, 2000).

2.5 Controls

controlling the occurrences of change orders and restraining their bad effect are highly recommended to analyze the controlling stage into three stages. These stages are design stage, construction stage, and design-construction interface stage.

2.5.1 Design stage controls for change orders

This stage consists of nine control tools which must be taken into consideration during design phase. These control tools are as follows:

1- **Review of contract documents**

Contract documents are the plans which the project works directly follow; so they must contain comprehensive and balanced change clauses to help improve coordination and communication (CII, 1994).

2- **Freezing design**

Owners' and users' desires play a bad role in producing change orders which

might be numerous . Therefore, closing the door for changes after the completion of the design freezes the design in a strong control method (CII, 1990).

3- Value engineering at conceptual phase

Value engineering is a great factor in saving cost, decreasing project time, initiating better quality, assisting clarifying project objectives, and reducing design discrepancies in design phase in construction projects (Arain and Pheng, 2005).

4- Involvement of professionals at initial stages of project

Involvement of professionals in the design stage leads the design to be more compatible, especially, in highly technical buildings such as health buildings (Arain and Pheng, 2005).

5- Owner's involvement at planning and design phase

The owner's involvement at the design phase would assist in discovering plans, scopes, specifications, and owner's requirements. This may result in avoiding change orders initiated by the owner (Arain and Pheng, 2005).

6- Contractor's involvement at planning and scheduling process

Contractor with his wield experience has the ability to give his suggestion to initiate better (Arain and Pheng, 2005).

7- Thorough detailing of design

Thorough detailing of design helps in identifying the errors and omissions in the design at an early stage (Arain and Pheng, 2005).

8- Clear and thorough project brief

Clear and thorough project brief is a good tool in restraining change orders that identify the project objectives to all the participants, which leads to reducing the noncompliance with the owner's requirements (Arain and Pheng, 2005).

9- Reducing contingency sum

The provision of a large contingency sum may lead to a number of change orders because the designer may not develop a comprehensive design (Arain and Pheng, 2005).

2.5.2 Construction stage controls for change orders

This stage consists of ten control tools which must be taken into account

during construction phase. These control tools are follows:

1- Clarity of change order procedures

The change order procedures are an integral part of effective management of change orders. The procedures should be identified and made clear to all parties early in the project. This in its turn which will help in reducing the processing time and other mishandling issues (Arain and Pheng, 2005; Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

2- Written approvals

The owner should approve and write down any change in the work that involves a change in the original price before a change order can be executed (CII, 1990). Any party signing on behalf of the owner must have a written authorization from the owner; otherwise it would be difficult to prove the right for compensation if there is no such authorization from the owner. In the busy environment of construction, many verbal agreements could be forgotten, which will leave the contractor without any legal proof to get compensation for the changes (Arain and Pheng, 2005; Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

3- Change order scope

The professional teams , in order to recognize and plan appropriately to minimize the negative impact of the change, should have a well defined scope .The clarity of the original scope helps to distinguish between a change of scope and a change due to design development. Arain and Pheng (2005) pointed out that a common disagreement between parties in a project was about defining the change scope. Therefore, the effective definition of the scope of work is very important to identify and manage changes.

4- Change logic and justification

One of the principles of effective change management is change logic and justification for implementation, which should be classified as required or elective. Required changes were those which verified the original objectives of the project, while elective changes were additional features that enhanced the project. The acknowledgement of the logic and justification behind the proposed changes helps the professionals in promoting beneficial changes and eliminating detrimental changes (Arain and Pheng, 2005; Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

5- Project manager from an independent firm to manage the project

The involvement of a project manager from an independent firm would give a great help in eliminating changes that arise due to the lack of coordination among professionals. This practice may be useful in reducing design discrepancies through early reviews of the contract documents and drawings (Arain and Pheng, 2005).

6- Restricted pre-qualification system for awarding projects

project bids should go through a restricted pre-qualification system for awarding projects which will act as a filter to select only the capable parties for any project. However, the lack of such system may permit incapable parties to win the bid, which may eventually lead to numerous problems in the later stages of a construction project (Arain and Pheng, 2005).

7- Owner's involvement during construction phase

The involvement of the owner during the construction stages would give a great help in identifying noncompliance with the requirements and in approving the changes promptly. Finally, the involvement of the owner during the construction stages may keep him aware of ongoing activities and help in decision making (Arain and Pheng, 2005).

8- Avoidance of use of open tendering

Contractors ,when competing in an open tendering, are usually encouraged to price very low in order to win the contract, especially in depression times when jobs are rare. This kind of system would give rise to the contractor trying to claim more to compensate for the low price. In order to eliminate the risks of unfair bids and changes that may arise due to the contractor's bidding strategy, open tender should be prevented (Arain and Pheng, 2005).

9- Use of project scheduling/management techniques

It is necessary to be flexible when dealing with change orders and have a flexible schedule to manage it. CPM, PERT are the most known scheduling techniques in the construction industry, but the schedule must have the ability to include impact of change orders in it in any time (Arain and Pheng, 2005)

10- Comprehensive documentation of change order

Participants keep their rights through timely notifications and documentations

of change orders which give them the option to pursue a subsequent claim or to defend against it. One of the worst conditions that affect change order is the length of time that happened between the announcing of the proposed contract modification and the rejection or approving of it (Arain and Pheng, 2005).

The documentation of change orders and claims had assisted in tracking the effects of the change and claim events on time and cost. A documented source of knowledge about previous change orders would be helpful in making decisions concerning the appropriate handling of change orders (Arain and Pheng, 2005).

2.5.3 Design-Construction interface stage controls for change orders

This stage consists of nine control tools that must be taken care during the time between design and construction. These control tools are as follows:

1- **Prompt approval procedures**

The length of time that elapses between a proposed contract modification is first announced until the matter is finally rejected or approved as a change order is one of the most aggravate conditions. However, if the period is long between recognition and implementation, the change will be more costly. Hence, instantaneous approval procedures would give a great help in reducing the bad effects of changes in the construction project. (Arain and Pheng, 2005; Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

2- **Ability to negotiate change**

One of the important factors for the effective control of change orders is the ability to negotiate changes. An effective negotiation can be greatly helpful for the professional team to minimize the negative impacts of the changes (Arain and Pheng, 2005). Effective negotiation of change orders requires certain skills, i.e., the awareness of contract terms, equipment, technology, project details, labor rates, methods and communication skills (Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

3- **Valuation of indirect effects**

Consequential effects, which is vital to evaluate them through the acknowledgement of this possibility and the establishment the mechanism for them, occur later in the downstream phases of a project. Indirect effects of changes can be

important in the downstream phases of a complex project; therefore, in order to manage the change order effectively, professionals should evaluate the total overall effects a change may have on the downstream phases of a project (Arain and Pheng, 2005; Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

4- **Team effort to control change orders and coordination**

Good coordination between owner, consultant, and contractor is a great factor in controlling change orders impact (CII, 1994), as it assists to manage the change orders at the early stage. (Arain and Pheng, 2005; Al-Dubaisi, 2000).

5- **Utilize work breakdown structure**

A work breakdown structure (WBS) is an effective tool for identifying and defining work. If a change involves work which is not previously included in the WBS, it can be logically added to the WBS and its relationship with the other WBS elements can be easily checked (Arain and Pheng, 2005).

6- **Control the potential for change orders arising through contractual clauses**

The selection of the appropriate contract form which includes the necessary and clear change clauses would be helpful in the management of change orders (Arain and Pheng, 2005). Benefits such as shifting risks and improved communication channels could result from a well done change clauses (CII, 1990). Obvious procedures written and presented in the contract and fair allocation of risks can help in resolving quarrels through negotiation rather than suing (Arain and Pheng, 2005).

7- **Comprehensive site investigation**

Comprehensive site investigations during the design phase assist in discovering any uncovering site condition, as differing site conditions have a clear impact on time and cost in large building projects. Therefore, a comprehensive site investigation would help in reducing potential changes in a project (Arain and Pheng, 2005).

8- **Use of collected and data compiled by owner, consultant and contractor**

The change orders should be documented to build a data base which can help in a further research study, that means, the institutions must share their documents with any researcher to help in controlling change orders and their bad impact (Arain

and Pheng, 2005).

9- **Knowledge-base of previous similar projects**

Project strategies and philosophies should take advantage of learned lessons from past similar projects. Sometimes the same sectors of building have the same change orders, which is possible to be avoided if the parties of the project take the lesson from previous similar projects (Arain and Pheng, 2005).

2.6 Change order management process reengineering

There are some logical steps that must be followed to reach to good management of change orders. These steps are:

1- Gathering historic change order data
2- Gathering supplier feedback
3- Sorting and preliminary analysis of data
4- Statistical analysis of finding data
5- System revisions formulation and report
6- implementation planning, and implementation (Doran and Bridgers, 2002).

2.7 Theoretical Model for Change Orders

Chao-Ying (2005) successfully modeled the construction process data in Repcon, a research system developed in the University of British Columbia. However, due to the lack of good data analysis technology, its functionality of enhancing all management functions is limited.

Yitmen et al (2006) presented an expert system named QUICOPP, which quantifies the impact of change orders on project performance in terms of cost and time. The system analyzes the factors contributing to adverse effects of change orders and provides recommendations to all parties who are associated with a project in resolving claims regarding those changes at any stage of a project.

The means by which latency disrupts construction is explored through a framework that finds connections among scope, process, and performance. This framework is converted into a working simulation model using System Dynamics to apply it to a real-world construction project (Lee and Pena-Mora, 2006).

Motawa et al (2004) aimed to identify and forecast potential changes and developed solutions before the change occurs. They presented the system architecture

of a proposed fuzzy model that attempts to estimate the likelihood of occurrence of a change event and predict the effect of change on project parameters using data that is realistic to obtain. Modeling construction change should consider the link between these main elements: project characteristics that lead to change, causes of change, the likelihood of change occurrence, and the change consequence.

Arain (2005) developed knowledge-based decision support system (KBDSS) to manage change orders. It is important to understand that the KBDSS for the management of changes is not designed to make decisions for users, but rather it provides pertinent information in an efficient and easy-to-access format that allows users to make more informed decisions. The model consists of six fundamental stages linked to two main components, a knowledge-base and a controls selection shell for making more informed decisions for effective management of change orders. The database will be developed through collecting data from source documents of past projects, questionnaire survey, literature review and in-depth interview sessions with the professionals who were involved in the projects. The knowledge-base will be developed through initial sieving and organization of data from the database (Arain and Pheng, 2005).

Arain and Pheng (2006b) developed the previous system according to the flow chart depicted in Figure 2.5.

Then, Arain and Pheng (2006a) developed Arain and Pheng (2006b) system to become a model consists of six fundamental stages linked to two main components, a knowledge-base and a controls selection shell for making more informed decisions for effective management of change orders.

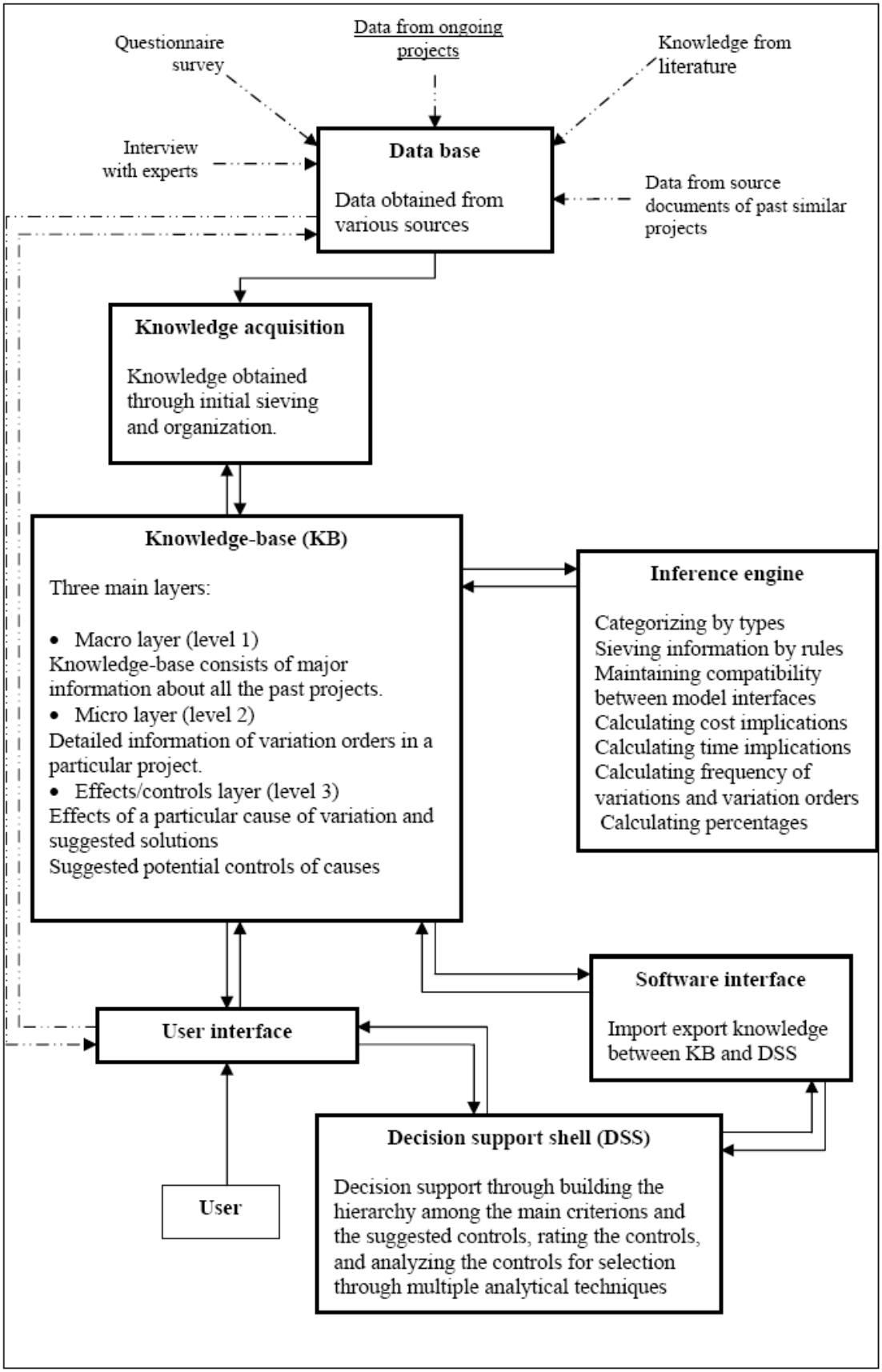


Figure 2.5: Framework for knowledge-based system (KBS) (Arain and Pheng, 2006b)

Chapter 3

Methodology

In order to realize the objectives of this study which are: determining major factors influencing the occurrences of change orders in the Gaza Strip; then determining their impacts on cost, schedule and productivity, and finally building a simulation model to model change orders occurrences and their impacts on building projects in the Gaza Strip. The methodology used in conducting this research consists of the following:

1- Literature review.
2- Case studies.
3- Interviews.
4- Analysis.
5- Building a simulation model.
    a- Model verification.
    b- Model validation.
6- Conclusion, recommendations, and further study**.**

The flow chart of the research methodology is shown in (Figure3.1) and the details of the above tasks are as follows:

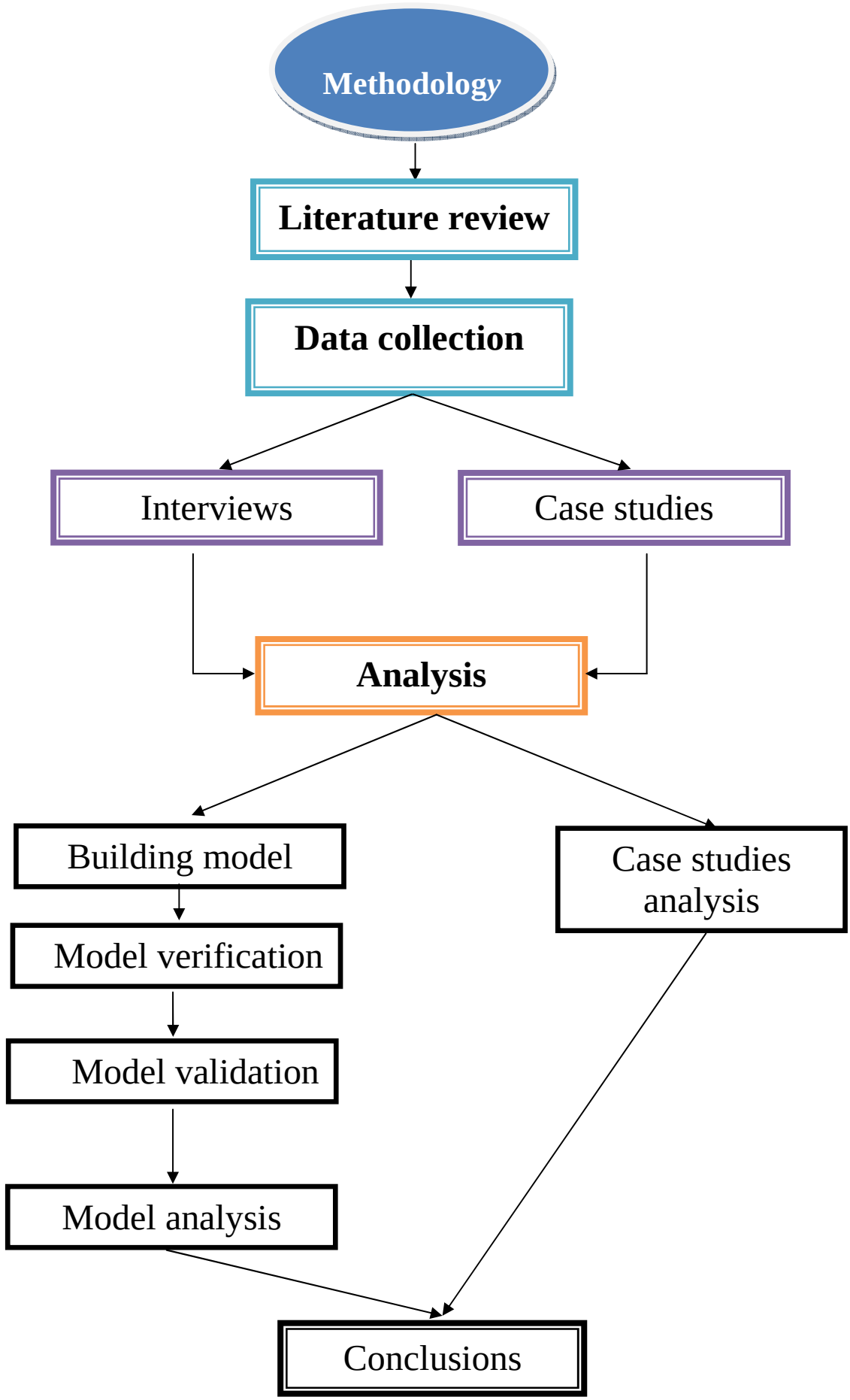


Figure3.1: Flow chart of the research methodology

3.1 Literature Review

Developing a better understanding of the research objectives, a comprehensive literature review was conducted to achieve the following:

1- Determining the definition, types, and actions related to change orders.
2- Identifying major factors influencing the occurrences of change orders.
3- Identifying the impact of changes on time and the methods to measure factors of delay.
4- Identifying the impact of changes on productivity and the methods to measure productivity losses during changes.
5- Identifying the impact of changes on cost and the methods to measure the variation of the cost.
6- Collecting previous methods which was used in building simulation models.

After relevant literature has been reviewed, the main factors causing change orders were collected as shown in Table 2.1. The techniques of measuring the impact then were chosen.

3.2 Data Collection

Information for the study was obtained from different sources such as documents from the education department, health department, completed residential projects, through personal interviews, and in-depth discussions with the professionals, consultants, and contractor involved in projects

Data were collected in a concurrent form from case studies and interviews. Following is a detailed description of how each method was used.

3.2.1 Case studies

Case studies approach used in this study encompassed 6 education building projects, one of which was rehabilitation. Case studies also encompassed 4 health building projects, two of which were rehabilitation. In addition, residential building projects carried out in the Gaza Strip were also investigated to collect the information required for in-depth study and analysis. The projects were documented and analyzed between 1996 and 2005. The purpose of case studies approach was to obtain data from the source documents of the completed projects. The source documents included the contract documents, variation orders documents, contract drawings, bill of

quantities, schedules, and reports.

Institutions like United Nations for Refugees and Works Agency (UNRWA), United Nations Development Program (UNDP), Palestinian Economic Council for Development and Reconstruction (PECDAR), Palestinian Housing Council, and Ministry of Public Works and Housing were chosen for the case studies. However, responses from them varied. The UNDP, for example, refused to give any document or information. UNRWA, on the other hand, said that they could provide data only from the memory of their engineers. As the Ministry of Public Works and Housing lost all its documents in the last war on Gaza, no cases were taken from them. Because PECDAR facilitated full access to all documents, so a lot of cases were taken from them. A clear system of documentation was used by Palestinian Economic Council, so it helped the researcher very much in studying change orders and their impact on building projects performance. As the Palestinian Housing Council also allowed full access to their full documents, all residential cases were taken from them. A good documentation system was used by Palestinian Housing Council, which greatly facilitated the researcher's collection of data concerning change orders and their impact.

All case studies included in this current research are formal building projects with owners, contractors, consultants, and the contract types were unit-price contracts. The owner of all case studies was the Palestinian Authority.

The following tasks were conducted:

1- The data of the case studies were collected from full documents such as contract documents, monthly reports, weekly reports, daily logs, bill quantity, schedule, claim documents, price offers, memorandums, letters between consultant and contractor, letters between consultant and owner, and drawings. Obtaining data from different sources contributed to determining the accuracy of every change order and its impact on cost and time.

2- From the case studies and interviews, the major factors influencing the occurrences of each change were determined.

3- The impact of each change order on cost and time was determined from projects' documents and interviews.

4- Other factors related to productivity were determined from the concurrent case studies and interviews.

5- After finishing previous task the data was filled in Table 4.20 to be used in the

analysis.

3.2.2 Interviews

An interview approach encompassing three main phases was carried out in this research in Gaza Strip aimed at collecting the required information for in-depth study and analysis. The interviews were conducted after the completion of the literature review and continued to the end of the research. The phases of the interview approach are as follows:

3.2.2.1 Decision making interview phase

This phase of interviews started directly after literature review was finished with two construction managers experts to achieve the following:

1- Making some use of their experiences, and discover other effective factors.
2- Choosing the best method to measure the impact on performance from these methods which have been collected in literature review.
3- Taking some idea about the number of case studies which may be taken in the research.

3.2.2.2 Concurrent with case studies phase

This phase of interviews was done concurrently with case studies, The parties of each case study were involved in these interviews. These interviews aimed at the following:

1 Collecting project documents (See Figure3.2.1) and determining every change which had happened and every cost and time that the contractor had claimed.
2 Contacting the contractor and making an interview with him to discuss any unclear points, cost and time estimate, and the project's productivity curve.
3 Contacting the consultant and discussing the project parameter with him.

These interviews were conducted to evaluate the impact of changes on their projects' performance.

3.2.2.3 Final phase

This stage of interviews was done after building the simulation model, i.e. at the final stage of research. At this stage, two expert construction managers were

interviewed to achieve the following:

1- Knowing the consultants' opinions about the validity of the simulation model.
2- Benefiting from their experience in writing the research conclusion and recommendations.

3.2.3 Final data collection stage

After finishing data collection, not only every factor causing change order was collected as seen in Table 3.1, but also impact on cost time, and productivity loss factors during change were determined.

Table 3.1: Summary of data collection

Serial number	Factors	Occurrences of changes	% impact on cost	% impact on schedule	Impact on productivity
1	Factor 1	N1, N2..	X1, X2 ..	Y1, Y2 …	Formula
2	Factor 2				
3	Factor 3				
N	Factor N				

3.4 Measuring Techniques

There were four stages of measuring techniques pertinent to this research. These stages are as follows:

1- Occurrences of change order measuring technique.
2- Cost impact measuring technique.
3- Time impact measuring technique.
4- Productivity impact measuring technique.

3.4.1 Occurrences of change order measuring technique

All change orders occurrences were taken from the documents of each case study and discussed with the parties to avoid any mistake.

3.4.2 Cost impact measuring technique

In this research only the direct impact on cost was taken into consideration, and the value of this impact was taken from the memorandums of negotiated change

orders cost. The approval between owner and contractor was taken as a direct impact on cost.

3.4.3 Time impact measuring technique

In this research only the delay in critical path was taken into consideration, The value of this impact was taken from the memorandums of negotiated change order time extension. The suitable approved extensions on time between owners and contractors were taken as the impact on time.

3.4.4 Productivity impact measuring technique

The technique which was chosen to calculate the impact of change orders on productivity is CII (2000) method which provided a quantitative method for both owners and contractors to determine if change impacted a project, and to provide a model for determining the probable magnitude of that impact on labor efficiency, especially in labor-intensive fields. The CII (2000) developed a linear regression equation to predict the magnitude of impact of change orders on labor productivity. The research team found that only six factors out of all the influencing factors had the most significant impact. The linear regression equation to predict the magnitude of impact of change orders on labor productivity (% productivity loss) is as follows:

$$\begin{aligned}\%\text{Delta} = {} & 0.37 + 0.12\,\text{Percent Change} - 0.08\,\text{PM \% Time On Project} \\ & - 0.17\,\%\,\text{OwnerInitiatedCO} - 0.09\,\text{Productivity} \\ & - 0.05\,\text{Overmanning} + 0.02\,\text{Processing Time}\end{aligned}$$

The definition of each of the independent factors listed in the above equation is given in (Table 2.2).

3.5 The Statistical Sample

Three restrictions were imposed on the selection process of respondents:

1- Restricted to projects (200000$ or more).
2- Restricted to contractors (Class A and B).
3- Restricted to building projects (education buildings, health buildings, and residential buildings).
4- The size of the sample was 15 case studies.

3.6 Analysis

The data were analyzed by two ways, these ways are as follows:

1- Statistical analysis
2- Simulation model analysis

3.6.1 Statistical analysis

Statistical analysis was used to analyze the data to rank the factors according to their occurrences and impacts.

Firstly sectors of buildings were analyzed separately to find the strength of change orders occurrences and then to find the mean of their impact on time, cost, and productivity. After that, all projects were analyzed together to find the strength of change orders occurrences and then to find the mean of their impact on time, cost, and productivity as shown in (Figure3.2).

3.6.1.1 Sectors analysis

At this stage, the data collected from the case studies and interviews were analyzed separately in order to study the occurrences of change orders and their impact on projects performance of health building, then on education building, and eventually on residential building.

Initial analysis at this stage aimed to find the most effective factors that cause occurrences of change orders in each sector of buildings by calculating the probability of occurrences for each factor by taking all changes as the sample space, and then the probability of each factor determined as depicted in (Equation 3.1).

$$P(Factor) = \frac{\text{times of its occurrences}}{\text{total change orders occurrences}} \quad \text{..... eq 3.1.}$$

After that the data was analyzed according to cost impact, time impact, and percentage of change on the project in terms of original budgeted work hours' impact to find out the factors having huge impact by calculating the mean of each factor and then ranking them according to the mean.

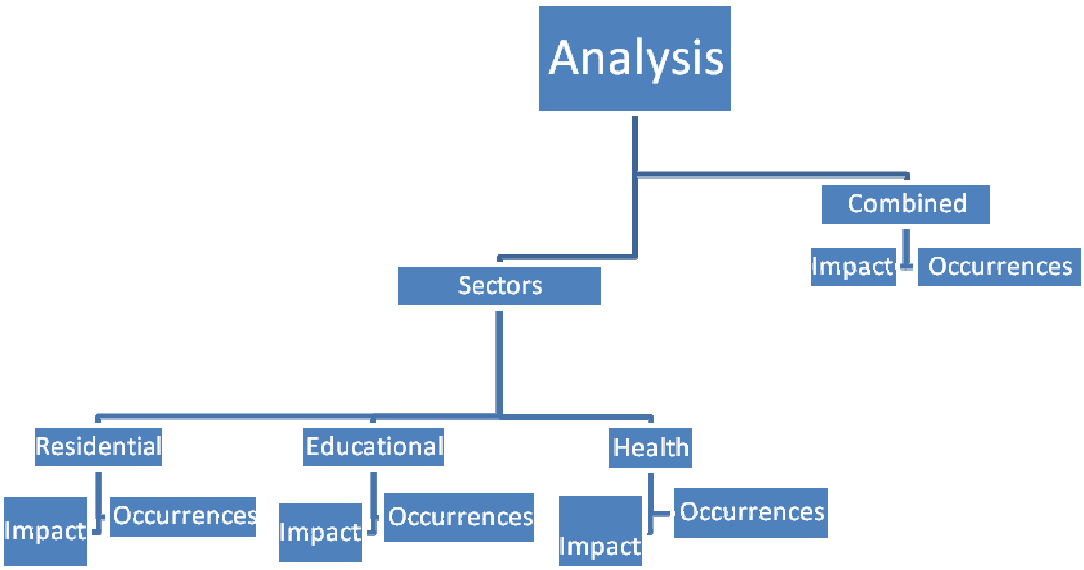


Fig 3.2: Analysis methodology

3.6.1.2 Combined analysis

At this stage, all data that had been collected from the case studies and interviews were analyzed together to study the occurrences of change orders and their impacts on the building projects performance in the Gaza Strip.

Initial analysis at this stage aimed to find the most effective factors that cause occurrences of change orders by calculating the probability of each factor occurrences as previously shown in (Section 3.4.1.1).

After the data was analyzed according to cost impact by finding the mean of each factor's impact, factors was ranked to find out which factors had the hugest impact.

3.6.2 Simulation model analysis

Arena simulation model used to analyze the data where the probability distribution of each factor and its impact was calculated to build the Arena simulation model as the following:

Firstly, data which was collected from the case studies and interviews was filled in (Table 4.20). That means not only every occurrences of change orders and each impact of cost and time due to this occurrences were recorded in Table 4.20, but also (Percent of change on project in terms of original budgeted work hours), (Percent of

time the project manager spends on the project), and (Percent of change orders initiated by the owner) were collected.

Secondly, the percentage change orders impact on cost was calculated was according to (Equation 3.2).

$$\%cost\ impact = \frac{\text{cost of the change order}}{\text{contract value}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.2.$$

The percentage change orders impact on time was calculated according to (Equation 3.3).

$$\%Time\ Impact = \frac{\text{extension of the time}}{Time\ of\ projet} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.3.$$

The percent of change on project in terms of original budgeted work hours was calculated from the agreed cost analysis that submitted during the negotiation, sometimes the percent of change on project in terms of original budgeted work hours was calculated from the cost breakdown analysis of the contract or from the interviews at the case studies collection phase.

The percent of time the project manager spends on the project was calculated for each case from the consultant's daily logs and the probability distribution for the factor was generated.

The percent of change orders initiated by the owner was calculated from the change orders documents.

The impact on productivity was generated by adding all previous factors in Arena program.

Thirdly, the following procedure was followed to build the simulation model

a) The time of project in the model was assumed by one day (model time).
b) The occurrences of change orders were modeled as time per arrival between entities which mean everyone was considered as change orders
c) To convert the occurrences of each factor to time the following question was asked. The question was supposed to be "What is time that resource needs to produce the occurrences of change orders?" The answer was "it is shorter than the time needed to produce the occurrences, T = $\frac{1}{\text{Occurrences}}$ and more than the time needed to produce the occurrences + 1, T = $\frac{1}{\text{Occurrences} + 1}$. So the answer was clarified in (Equation 3.4).

$$\frac{1}{2} \times \left(\frac{1}{\text{Occurrences}} + \frac{1}{\text{Occurrences} + 1}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eq\ 3.4.$$

d) In impact on cost and schedule the distribution was calculated directly by entering the value in input analyzer and finding out their distribution.

e) Table 3.2 shows an example of the summary of distributions.

Table 3.2: Factors distribution

Factor	Service time	Cost distribution function	Schedule distribution function
F1	0.3	NORM(Mean, Std Div)	EXPO(Mean)
F2	0.49	TRIA(Min , Mode , Max)	WEIB(Beta , Alpha)
F3	0.9	UNIF(Min , Max)	Constant

3.7 One-Sample Kolmogorov-Smirnov Test

Kolmogorove- Smirnov test was used to identify if data followed a normal distribution or not. This test is considered necessary in case of testing hypotheses as most parametric test stipulate data to be normally distributed. The test results, as shown in chapter 5, clarify that the significant level calculated is greater than 0.15 (sig. Ok); this in turn denotes that the data follows normal distribution, and so a parametric test must be used.

3.8 Building a Simulation Model

At this stage, data collected by means of Interviews and case studies were used to build an Arena simulation model. Then, the impact of changes on cost, schedule, and productivity was revealed when the changes were input. The simulation model is shown in the flow chart in (Figure 6.1 and 6.2)

3.9 Model Verification

Two methods were used to check the model verification; the first was by reviewing the model step by step with the supervisor to insure that there was no error and the second way was by inserting the result of each case study on the model and comparing the results by calculating the mean of the error after that, by doing bivariate correlations and categorical regression tests.

3.9.1 Bivariate correlations

Bivariate correlations test was used to compare between simulation result with the project results. Bivariate Correlations procedure computes Pearson's correlation coefficient, Spearman's rho, and Kendall's tau-b with their significance levels. Correlations measure how variables or rank orders are related. Before calculating a correlation coefficient, screen data for outliers (which can cause misleading results) and evidence of a linear relationship. Pearson's correlation coefficient is a measure of linear association. Two variables can be perfectly related, but if the relationship is not linear, Pearson's correlation coefficient is not an appropriate statistic for measuring their association.

3.9.2 Categorical regression

Categorical regression was used to compare between simulation result with the project results. The use of Categorical Regression is most appropriate when the goal of analysis is to predict a dependent (response) variable from a set of independent (predictor) variables. As with all optimal scaling procedures, scale values are assigned to each category of every variable such that these values are optimal with respect to the regression. The solution of a categorical regression maximizes the squared correlation between the transformed response and the weighted combination of transformed predictors.

6.10 Model Validation

Validation of the simulation model of change orders and their impact on cost, time, and productivity was done in two ways. The first was through two interviews with two expert construction managers. The second was by entering a new case on the model and comparing its results.

3.11 Conclusion, Recommendations, and Further Studies

Finally, the fulfillment of the objectives of this research was tested, and this led to listing some recommendations.

The problems were discussed. After that further studies were suggested.

Chapter 4

Data Collection

A combination of concurrent interviews and case studies were used to collect change orders occurred in 15 building projects and their impact on building projects performance.

The case studies encompassed 6 education building projects, 4 health building projects, 5 residential building projects, which were carried out in the Gaza Strip to collect the information required for analysis. The projects which were documented and analyzed were only initiated between 1996 and 2005.

4.1 Summary of Case Studies

Table 4.1 shows the main characteristics of each project taken as a case study where

PC = Percentage of change on project in terms of original budgeted work hours

PM= Percentage of time the project manager spends on the project.

IO= Percentage of change orders cost initiated by the owner.

Table 4.1: Characters of the case studies

					Cost impact		Time impact	Productivity impact		
Case	Sector	Construction Type	Original Duration	Contract Value ($)	% Increase	% Decrease	% Extension	PC	PM	IO
Case 1	Health	New	540 days	1470821	59.2	27.7	19	39	95	56
Case 2	Health	New	215 days	281007	17.25	17.51	14	23.3	95	10.2
Case 3	Health	Rehabilitation	120 days	185885	7.9	0	21	13.7	95	2.3
Case 4	Health	Rehabilitation	90 days	629350	13.8	1.5	0	7.3	95	3.6
Case 5	Education	New	300 days	869278	10.8	2.8	10	5.6	40	32.8
Case 6	Education	New	300 days	869278	5.9	0	0	3.9	95	71.5
Case 7	Education	Rehabilitation	180 days	209950	26.1	0.3	90	24.3	95	13.7
Case 8	Education	New	300 days	716573	18.8	0.1	10	18.1	70	49.8
Case 9	Education	New	300 days	735280	17.8	2.5	12	18.4	85	24.9
Case 10	Education	New	300 days	716573	7.6	0	12	5.3	90	24.9
Case 11	Residential	New	365 days	706965	8.9	1.47	60	7.8	95	23.6
Case 12	Residential	New	365 days	477334	8.7	3.77	50	5.3	95	14.4
Case 13	Residential	New	240 days	276879	1.5	0	0	2.1	95	0
Case 14	Residential	New	240 days	587528	6	3.1	26	6.05	85	8
Case 15	Residential	New	240 days	564475	10.2	3.7	0	14.17	95	92

4.2 Major Factors Causing Change Orders

While reviewing relevant literature, the researcher collected 98 factors causing change orders. However, after finishing the case studies, it was found out that only 35 of them were effective in the Gaza Strip building industry.

After finishing interviews and case studies, another two effective factors in the Gaza Strip building industry were collected in addition to the above 35 factors. The new two factors were Israeli closure and suggestions to initiate more quality. The effective factors that were collected are illustrated in (Table 4.2).

Table 4.2: Factors causing change orders in Gaza Strip building industry

Serial	Groups number	Group name	Factors number	Factor name
1	1	Design errors	1	Design errors
2			2	Omissions
3			4	Inconsistencies
4			5	Impossibilities
5			6	Change in design request
6			8	Inadequate design
7			15	Noncompliance of design with owner's requirements
8	2	Changes in market conditions	18	Specified item became unavailable
9	3	Scope and quantities of work	21	Significant changes in the quantities of work
10			27	Plan errors
11			29	Change of plans or scope by owner
12			31	Change in the owner's requirements
13			32	Owner desire to improve his financial conditions
14	4	External conditions	39	Uncovering disclosed existing conditions
15			41	Strikes
16			42	Extreme weather condition
17			43	Material non- availability
18			44	Israeli closure

Table 4.2: Factors causing change orders in Gaza Strip building industry (contd.)

Serial	Groups number	Group name	Factors number	Factor name
19	5		47	Differing site conditions
20		Differing Site	48	Safety considerations
21		Conditions	49	Differing subsurface conditions
22	6		52	Suggestions to initiate more economical construction
23		Suggestion to	53	Suggestions to initiate more quality
24		initiate better	54	Value engineering
25	7	Changes in design preference	56	Delays in the project
26	8		69	Consultant's lack of judgment and experience
27		Contract	71	Honest wrong beliefs of consultant
28		conditions	80	Contractor's lack of judgment and experience
29			83	Utility companies
30			85	Local governments
31	9		87	Prevalent practice on this project and/or district.
32			90	User needs
33			91	Review of the project by the proper governmental agency
34		Actions by	95	Change in economic conditions
35		others	96	Socio-cultural factors
36		Final	98	Mechanical and electrical provision
37	10	coordination without in contract equipment	100	Technology changes

4.3 Health Sector

4 health building projects were taken as case studies as follows :

1- The first one was a community health center in Deir El-Balah, but because the

occurrence of El-Aqsa Intifada the community center changed to a hospital. The owner of this project was the Ministry of Health and the contract type of this project was a unit price contract. The strategy of the contractor in this project was a partnering strategy. The delay in the project was 19 causable days with finishing date on 14/02/2001. The contract value was 1470821$, but the contract close up cost was 1972933.5$.

2- The second was a health clinic in Al-Zaitoon in Gaza. The owner of this project was the Ministry of Health. The contract type of this project was a unit price and the delay of this project was 14 causable days. The contract value was 281007.06 $, but the contract close up cost was 278571.7 $. The relationship between the contractor, consultant, and owner wasn't good.
3- The third was a community health center in Deir El-Balah and it consisted of adding a new storey and some rehabilitation. The owner of this project was the Ministry of Health and the contract type of this project was a unit price. The delay of this project was 52 days, but only 21 days were causable. The main reason for the delay was a not enough of contractor crews to perform. The contract value was 185885.99 $ and the relationship between the contractor, consultant, and owner wasn't a good one and there were some disputes among them.
4- The fourth was adding a storey and additional new building C in Nasser hospital - Khan Younis and doing some rehabilitation. The owner of this project was the Ministry of Health and the contract type of this project was a unit price. The delay of this project was 6 non-causable days. The main reason for the delay was the intensity of change orders. The contract value was 629350 $ and the relationship between the contractor, consultant, and owner was a good one.

Table 4.1 summarized the impact on projects performance and the details of these health projects was shown in Table 4.3. for more detail review Annex (1 and 2).

In this section all change orders which happened in 4 health projects were collected. After that the impact of each change order in cost, time, and percentage of change on the project in terms of original budgeted work hours were counted. Table 4.4 shows occurrences of change orders and their impact.

Table 4.3: Health case studies

Case number	Owner	Contractor	Schedule start date	Actual Start date	Duration (days)	Actual finish date	Contract value ($)	Actual closed cost($)
1	Ministry of Health	Salama Co.	25/07/ 1999	15/08/ 1999	540	14/02/ 2001	1470821	1972933
2	Ministry of Health	Al Rafe'a Contracting company	15/10/ 1996	23/10/ 1996	215	15/07/ 1997	281007	278571.7
3	Ministry of Health	Abu Shammala & Abu Dan Co.	27/01/ 2003	30/01/ 2003	120	22/07/2003	185886	No Data
4	Ministry of Health	El Farra Bros Co.	01/10/ 2003	01/10/ 2003	90	06/01/2004	629350	709400

Table 4.4: Frequency of change orders and %impact on performance for health sector

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% $PC^{(1)}$ impact per each occurrence
1	1	5	0.15, 0.13, 0.4, 0.57, 0.06	No Impact	0.6, 0.05, 0.22, 0.11, 0.01
1	2	1	-0.16	No Impact	No Impact
1	4	2	0.1, 0.08	No Impact	0.04, 0.15
1	5	1	1.37	No Impact	0.26
1	6	2	2.89, -3.43	No Impact	0.24, 0.04
1	8	16	1.47, 0.02, 0.01, 0.21, 0.05, 0.05, 0.04, 0.5, 0.31, 0.15, 0.07, 3.1, 0.3, 0.1, 0.18, 0.13	No Impact	5.44,0.02, 0.01, 0.08, 0.49, 3.46, 0, 0.03, 0.03, 0.84, 0.05, 0.05, 0.03, 0, 0.3, 0.1
1	15	5	0.04, 0.34, 1.19, 1.89, 4.84	No Impact	0.08, 0.24, 4.19, 0.95, 0.07

Table 4.4: Frequency of change orders and %impact on performance for health sector (contd.)

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC[(1)] impact per each occurrence
3	21	32	2.25, 0.53, 0.9, 0.94, 0.32, 0.44, 0.06, 0.28, -0.09, 0.68, 0.37, 0.58, 0.63, 0.17,0.13, 0.55, 0.31, 0.24, 0.2, 0.16, 0.06, 0.05, 0.06, 0.05, 0.05, 0.53, 0.05, 0.03, -0.13, -0.08, -0.06, -0.41,	No Impact	3.56, 0, 0, 0, 0, 0, 0, 0, 12.73, 0.17, 0.25, 0.03, 0.21, 0.07, 0.04, 0.11, 1.87, 0.1, 0.08, 0.21,0.23, 0.19, 0.04, 0.03, 0.02, 0.02, 0.02, 0.01, 0.01, 0.05, 0.01, 0.01
3	27	1	0.1	1.3	0.5
3	29	2	11.54	0.93, -5.56	17.1
3	32	19	-2.72, -0.03, -0.55, -3.1, -0.63, -0.08, -1.37, -0.73, -0.94, -0.47, -1.05, -0.52, -5.06, -0.1, -0.26, -0.1, -0.04, -0.08, -0.08	No Impact	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0.81, 5.66, 0.98, 2.65, 0.55
4	43	2	0.41, 1.13	0, 5.83	0.28, 0
4	44	1	0	11.67	0
5	47	1	3.08	No Impact	2.29
5	48	6	0.06, 0.4, 003, 0.1, 0.38, 1.02	No Impact	0.16, 0.07, 0.05, 0.01, 0, 0.01
5	49	2	0.41, 0.1	No Impact	0.16, 0.04

Table 4.4: Frequency of change orders and %impact on performance for health sector (contd.)

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC[(1)] impact per each occurrence
6	53	6	0.06, 1.62, 1.9, 0.15, 0.29, 0.27	No Impact	0, 0, 0, 0.03, 0.06, 0.01
6	54	1	4.82	0.37	7.14
7	56	1	2.72	No Impact	0
8	69	1	0	1.48	0
8	71	1	0.18	No Impact	0.04
8	80	1	0.09	No Impact	0
9	85	1		0.01	0
9	87	3	1.25, 9.52, 0.11	No Impact	0.03, 1.89, 0.13
9	90	2	0.65, 0.22	No Impact	0.48, 0.04
9	91	1	0.04	4.63	0.17
9	96	1	0.38	No Impact	0.7
10	98	1	0.01	No Impact	0.04
10	100	2	0.17, 0.13	No Impact	0.48, 0.12

[(1)]Percentage of Change on project in terms of original budgeted work hours

4.4 Education Sector

In this research 6 education building projects, one of which was rehabilitation, were taken as case studies.

1- The first project was Al-Shejaa'ea Elementary School for Males. The project was a new construction school in Gaza city. The owner of this project was Ministry of Education. The contract type of this project was a unit price. The delay of this project was 13 days, only 10 of which were causable. The main reason for the delay was the plan error but the cause of the non-causable delay was the productivity loss. The contract value was 869278 $ and the relationship between the contractor, consultant, and owner wasn't a good one

2- The second projects was a new construction for Sheikh Radwan School in the City of Gaza. The project owner was the Ministry of Education. The contract type of this project was a unit price and there was no delay on this project. The contract value was 869278 $ and the relationship between the contractor, consultant, and owner fluctuated between good and bad.

3- The third project was comprised adding a new classroom with rehabilitation in Al-Karmel Secondary School in the City of Gaza. The owner of this project was the Ministry of Education. The project contract type was a unit price. The delay of this project was 87 days, but the causable delay was 90 days. The main reason for the delay was differing site conditions and Israeli closures. The contract value was $209950 and the relationship between the contractor, consultant, and owner was a good one

4- The fourth project was a new construction for Khalid Bin Al Waleed School in Al-Nusirat Camp. The owner of this project was the Ministry of Education and the contract type was a unit price. The delay on this project was 7 days with 10 days of causable delay and the main reason for the delay was Israeli closures. The contract value was $ 716573 and the relationship between the contractor, consultant, and owner wasn't a good one.

5- The fifth project was a new construction of Nusairat Elementary Girl School in Al-Nusairat camp. The owner of this project was the Ministry of Education. This project contract type was a unit price and the delay of this project was 13 days with 12 days causable delay. The main reason for the delay was Israeli closure and the extreme whether condition. The contract value was $856439 and the relationship between the contractor, consultant, and owner was rather a good one.

6- The sixth project was a new construction of Al-Qezan School in Khan Younis. The owner of this project was the Ministry of Education and contract type was a unit price. The delay on this project was 19 days with 12 days causable delay. The main reason for the delay was Israeli closures and the extreme weather conditions and the non-causable delay was because the contractor did not use enough labor. The contract value was $735280.5 and the relationship between the contractor, consultant, and owner was a rather good one

Table 4.1 summarized the impact on projects performance and the details of these health projects was shown in Table 4.4. for more detail review Annex (1 and 2)

Table 4.5: Education case studies

Case	Owner	Contractor	Schedule start date	Actual start date	Duration	Actual finish date	Contract value ($)	Actual closed cost ($)
1	Ministry of Education	sadi for contracting & trading	02/11/ 1996	02/11/ 1996	300 Days	15/09/ 1997	869278	No Data
2	Ministry of Education	Shehab for contracting & trading	02/11/ 1996	02/11/ 1996	300 Days	02/09/ 1997	869278	No Data
3	Ministry of Education	Alemran palestinian group co	24/11/ 2002	24/11/ 2002	180 Days	21/08/ 2003	209950	237190.52
4	Ministry of Education	Al Hallaq Co.	08/06/ 1997	08/07/ 1997	300 Days	11/05/ 1998	716573	No Data
5	Ministry of Education	Al Hallaq Co.	08/01/ 1997	08/01/ 1997	300 Days	17/11/ 1997	856439	No Data
6	Ministry of Education	Al-Farra Co.	25/01/ 1997	25/01/ 1997	300 Days	10/12/ 1997	735280	No Data

In this section, all change orders taking place in 6 education building projects were compiled. After that the impact of each change order in cost, time, and percentage of change on project in terms of original budgeted work hours were counted. Table 4.5 illustrates those change orders and their impact.

Table 4.6: Frequency of change orders and %impact for education sector

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% $PC^{(1)}$ impact per each occurrence
1	1	7	0.06, 0.01, 0.02, 0.06, 0.06, 0.02, 0.13	No Impact	0.02, 0.04, 0.11, 0.02, 0.01, 0.01, 0.01

Table 4.6: Frequency of change orders and %impact for education sector (contd.)

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC(1) impact per each occurrence
1	4	2	0.29, 0.02	No Impact	0.32, 0.08
1	5	1	0.08	No Impact	0.02
1	8	34	0.35, 0.16, 0.02, 0.04, 0.06, 0.46, 0.25, 0.24, -0.04, 0.07, 0.36, 0.07, 0.11, 0.4, 0.7, 0.13, 0.37, 0.45, 0.1, 0.06, 0.01, 0.02, 0.69, 0.15, 0.38, 0.02, 0.04, 0.35, 0.16, 0.34, 0.06, 0.46, 0.25, 0.3	No Impact	0.41, 0.12, 0.01, 0.01, 0.03, 0.29, 0.04, 0.4, 0, 0.01, 0.27, 0.02, 0.02, 0.08, 0.07, 0.05, 0.21, 0.29, 0.15, 0.11, 0.01, 0.01, 0.26, 0.06, 0.32, 0.01, 0.01, 0.26, 0.12, 0.25, 0.01, 0.34, 0.09, 0.23
2	18	1	0.63	No Impact	0.06
3	21	9	0.63, 0.71, -1.34, 0.96, 0.25, 0.49, 0.03, 0.09, 0.95	No Impact	0.06, 0.84, 0, 1.69, 0.34, 1.19, 0.05, 0.08, 0.71
3	27	1	0.02	3.33	0.07
3	31	2	0.14, 0.14	No Impact	0.05, 0.05
3	32	1	-0.17	No Impact	No Impact
4	39	3	0.4, 1.21, 0.31	No Impact	0.29, 1.35, 0.23
4	42	2	No Impact	1.33, 1.33	No Impact
4	43	1	0.05	No Impact	No Impact
4	44	4	No Impact	25, 3.33, 2.67, 2.67	No Impact
5	47	5	13.02, 6.65, 0.1, 0.81, 0.69	25, 0,0,0,0	14.46, 6.1, 0.05, 0.6, 0.64
5	48	6	0.02, 0.14, 0.19, 5.84, 0.13, 0.31	No Impact	0.01, 0.17, 0.15, 5.41, 0.05, 0.36

Table 4.6: Frequency of change orders and %impact for education sector (contd.)

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC[(1)] impact per each occurrence
5	49	7	0.74, 0.59, 1.12, 1.77, -0.36, 6.1, 1.55	No Impact	0.14, 0.06, 0.42, 0.33, 0, 5.61, 0.58
6	52	3	-0.81, -0.09, -0.28	No Impact	No Impact
6	53	30	1.14, 0.24, 1.79, 0.08, 1.14, 0.24, 2.68, 3.62, 0.48, 0.81, 0.6, 0.06, 5.62, 1.56, 0.2, 0.05, 0.07, 0.02, 2.36, 0.21, 0.1, 0.01, 0.28, 0.05, 1.96, 0.05, 0.07, 2.28, 2.42, 0.32	No Impact	0.05, 0.01, 1, 0.01, 0.05, 0.01, 2.46, 2.69, 036, 2.2, 0.76, 6.1, 1.8, 0.22, 0.02, 0, 0, 0, 0, 0.01, 2.98, 0.08, 0.04, 0.01, 0.16, 0.02, 0.01, 0.04, 3.28, 0.13
7	56	1	No Impact	-1	No Impact
9	87	3	0.78, 0.14, 0.62	No Impact	0.73, 0.06, 058
9	90	7	0.12, 0.06, 0.02, 012, 0.01, 0.11, 0.065	No Impact	0.03, 0.22, 0.01, 0.16, 0.01, 0.1, 0.01
9	96	4	0.1, 0.04, 0.03, 0.03	No Impact	0.05, 0.04, 0.01, 0.01
10	98	1	0.12	No Impact	0.05

[(1)]Percentage of Change on project in terms of original budgeted work hours

4.5 Residential Sector

In this research 5 residential building projects were taken as case studies, two of which in Rafah city and three in the City of Gaza. The details of these projects are as follows.

1- The first project was a new housing building for the engineering institute in Rafah City. The owner of this project was the Ministry of Public Works and Housing. The contract type of this project was a unit price. The delay of this project was 53 days with 60 days causable delay. The main reason for the

delay was the Israeli closures. The contract value was $706965.49 and the relationship between the contractor, consultant, and owner was a good one

2- The second project was a new housing building for the Palestinian control and investigation board in Gaza City. The owner of this project was the Ministry of Public Works and Housing. The contract type of this project was a unit price. The delay of this project was 50 causable delays and the main reason for the delay was Israeli closures and differing subsurface conditions. The contract value was 477334 $ and the relationship between the contractor, consultant, and owner was a good one.
3- The third project was a new housing building in Rafah city. The owner of this project was the Ministry of Public Works and Housing. The contract type of this project was a unit price. The contract value was 276879.5 $ and the relationship between the contractor, consultant, and owner was a good one
4- The fourth project was a new housing building for the Palestinian Control and Investigation Board in Gaza City. The owner of this project was the Ministry of Public Works and Housing. The projects' contract type was a unit price. The project's delay was 37 days, but the causable delay was only 26 days. The main reason for the delay was Israeli closures and differing subsurface conditions. The contract value was 587528 $ and the relationship between the contractor, consultant, and owner was a bad one as the contractor strategy was claimer.
5- The fifth project was a new housing building for Personnel Department of the Palestinian Authority (Diwan Almothafeen) in Gaza City. The owner of this project was the Ministry of Public Works and Housing. The project's contract type was a unit price. The delay of this project was 22 days and it was non-causable delay. The reason for the delay was that the contractor company was a novice one in the field without any experience. The contract value was 564475 $ and the relationship between the contractor, consultant, and owner was a bad one.

Table 4.1 summarized the impact on projects performance and the details of these health projects was shown in Table 4.6. for more detail review Annex (1 and 2)

Table 4.7: Residential case studies

Case number	Owner	Contractor	Schedule start date	Actual start date	Duration	Actual finish date	Contract value ($)	Actual closed cost($)
1	Ministry of Public Works and Housing	Salah Al-Deen Co.	22/04/ 2006	22/04/ 2006	365 Days	14/06/ 2007	706965	744174
2	Ministry of Public Works and Housing	Al-Shehabia	23/04/ 2003	23/04/ 2003	365 Days		477334	473069
3	Ministry of Public Works and Housing	Salah Al-Deen Co.	05/07/ 2002	05/07/ 2002	240 Days	04/03/ 2003	276879	281174
4	Ministry of Public Works and Housing	Bonian	14/12/ 2003	13/08/ 2004	240 Days	19/05/ 2005	587528	604561
5	Ministry of Public Works and Housing	Hatawee Co.	20/04/ 2005	20/04/ 2005	240 Days	10/01/ 2006	564475	593254

In this section all change orders taking place in 5 residential projects were collected. Then, the impact of each change order in cost, time, and percentage of change on project in terms of original budgeted work hours were counted. Table 4.7 shows those change orders and their impact.

Table 4.8: Frequency of change orders and %impact for residential sector (contd.)

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC$^{(1)}$ impact per each occurrence
1	1	2	0.02, 0.2	No Impact	0.01, 0.22
1	4	3	0.05, 0, 0.03	No Impact	0.1, 0, 0.02
1	5	1	0.09	No Impact	No Impact

Table 4.8: Frequency of change orders and %impact for residential sector (contd.)

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC[(1)] impact per each occurrence
1	8	21	0.08, 0.07, 0.3, 0.06, 0.18, 0.2, 0.06, 0.51, 0.02, 0.22, 0.09, 0.09, 1.42, 0.19, 0.19, 0.03, 0.21, 0.06, 0.1, 0.11, 0.16	No Impact	0.04, 0.09, 0.3, 0.03, 0.1, 0.21, 0.06, 0.22, 0.01, 0.09, 0.01, 0.03, 1.31, 0.06, 0.08, 0.04, 0.02, 0.14, 0.25, 0.02, 0.26
3	21	4	0.34, 0.02, 0.03, 0.06	No Impact	0.37, 0.04, 0.03, 0.01
3	27	1	3.63	No Impact	3.36
3	29	1	3.6	No Impact	3.36
3	32	3	-0.49, -0.34, -0.09	No Impact	No Impact
4	41	1	1.400	No Impact	2.100
4	44	4	No Impact	16.1, 6.7, 3.5, 3.5	No Impact
5	48	12	0.1, 1.42, 0.45, 0.46, 0.02, 0.09, 0.11, 0.37, 0.014, 0.12, 0.07, 0.25	0,0,0,0,0,0 ,0,0,0,0, 0.28, 3.9	0.25, 1.31, 0.17, 0.43, 0.03, 0.06, 0.04, 0.28, 0.01, 0.05, 0.03, 0.21
5	49	2	0.98, 1.26	2.78, 1.25	0.4, 0.93
6	52	1	-0.57	No Impact	No Impact
6	53	8	0.6, 0.5, 0.73, 0.07, 0.06, 0.35, 0.02, 0.04	No Impact	0.75, 0.46, 0.67, 0.05, 0.05, 0.14, 0, 0.06
6	54	3	-3.77, -3.06, -3.19	No Impact	No Impact
8	71	1	3.12	No Impact	1.6
9	83	1	0.02	No Impact	No Impact
9	90	21	0.03, 0.3, 0.07, 0.53, 017, 0.21, 0.26, 0.01, 0.05, 0.02, 0.06, 0.04, 0.01, 0.05, 0.02, 0.02, -0.53, 0.16, 0.11, 0.08, 0.06	No Impact	0.01, 0.22, 0.03, 0.01, 0.19, 0.4, 0.42, 0.01, 0.05, 0.02, 0.05, 0.04, 0.01, 0.05, 0.02, 0.02, 0, 0.15, 0.08, 0.06, 0.05
9	91	1	No Impact	0.28	No Impact

Table 4.8: Frequency of change orders and %impact for residential sector (contd.)

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC[(1)] impact per each occurrence
9	95	7	0.38, 1.53, 0.48, 6.89, 1.3, 0.13, 0.6	No Impact	0.08, 1.99, 0.85, 11.25, 1.17, 0.11, 0.52
9	96	1	0.22	No Impact	No Impact
10	100	3	0.17, 0.15, 0.09	No Impact	0.084, 0.12, 0.032

[(1)]Percentage of Change on project in terms of original budgeted work hours

4.6 Summary of All Data

In this section all change orders which happened in 15 building projects were collected. After that the impact of each change order in cost, time, and (PC) percentage of change on project in terms of original budgeted work hours were counted. Table 4.8 shows those change orders and their impact.

Table 4.9: Frequency of change orders and %impact on performance

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC[(1)] impact per each occurrence
1	1	14	0.02, 0.2, 0.15, 0.13, 0.4, 0.57, 0.06, 0.06, 0.01, 0.02, 0.06, 0.06, 0.02, 0.13	No Impact	0.01, 0.22, 0.02, 0.04, 0.11, 0.02, 0.01, 0.01, 0.01, 0.6, 0.05, 0.22, 0.11, 0.01
1	2	1	-0.16	No Impact	No Impact
1	4	7	0.05, 0, 0.03, 0.1, 0.08, 0.29, 0.02	No Impact	0.1, 0, 0.02, 0.32, 0.08, 0.04, 0.15
1	5	3	0.09, 1.37, 0.08	No Impact	0, 0.26, 0.02
1	6	2	2.89, -3.43	No Impact	0.24, 0.04

Table 4.9: Frequency of change orders and %impact on performance (contd.)

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC[(1)] impact per each occurrence
1	8	71	0.08, 0.07, 0.3, 0.06, 0.18, 0.2, 0.06, 0.51, 0.02, 0.22, 0.09, 0.09, 1.42, 0.19, 0.19, 0.03, 0.21, 0.06, 0.1, 0.11 ,0.16, 1.47, 0.02, 0.01, 0.21, 0.05, 0.05, 0.04, 0.5, 0.31, 0.15, 0.07, 3.1, 0.3, 0.1, 0.18, 0.13, 0.35, 0.16, 0.02, 0.04, 0.06, 0.46, 0.25, 0.24, -0.04, 0.07, 0.36, 0.07, 0.11, 0.4, 0.7, 0.13, 0.37, 0.45, 0.1, 0.06, 0.01, 0.02, 0.69, 0.15, 0.38, 0.02, 0.04, 0.35, 0.16, 0.34, 0.06, 0.46, 0.25, 0.3	No Impact	0.04, 0.09, 0.3, 0.03, 0.1, 0.21, 0.06, 0.22, 0.01, 0.09, 0.01, 0.03, 1.31, 0.06, 0.08, 0.04, 0.02, 0.14, 0.25, 0.02, 0.26, 0.41, 0.12, 0.01, 0.01, 0.03, 0.29, 0.04, 0.4, 0, 0.01, 0.27, 0.02, 0.02, 0.08, 0.07, 0.05, 0.21, 0.29, 0.15, 0.11, 0.01, 0.01, 0.26, 0.06, 0.32, 0.01, 0.01, 0.26, 0.12, 0.25, 0.01, 0.34, 0.09, 0.23, 5.44,0.02, 0.01, 0.08, 0.49, 3.46, 0, 0.03, 0.03, 0.84, 0.05, 0.05, 0.03, 0, 0.3, 0.1
1	15	5	0.04, 0.34, 1.19, 1.89, 4.84	No Impact	0.08, 0.24, 4.19, 0.95, 0.07
2	18	1	0.63	No Impact	0.06
3	21	45	0.34, 0.02, 0.03, 0.06, 2.25, 0.53, 0.9, 0.94, 0.32, 0.44, 0.06, 0.28, 0.09, 0.68, 0.37, 0.58, 0.63, 0.17, 0.13, 0.55, 0.31, 0.24, 0.2, 0.16, 0.06, 0.05, 0.06, 0.05,	No Impact	0.37, 0.04, 0.03, 0.01, 0.06, 0.84, 0, 1.69, 0.34, 1.19, 0.05, 0.08, 0.71, 3.56, 0, 0, 0, 0, 0, 0, 0, 12.73, 0.17, 0.25, 0.03, 0.21, 0.07, 0.04, 0.11, 1.87, 0.1,

Table 4.9: Frequency of change orders and %impact on performance (contd.)

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC(1) impact per each occurrence
3	21	45	0.05, 0.53, 0.05, 0.03, -0.13, -0.08, -0.06, 0.95, -0.41, 0.63, 0.71, -1.34, 0.96, 0.25, 0.49, 0.03, 0.09,	No Impact	0.08, 0.21, 0.23, 0.19, 0.04, 0.03, 0.02, 0.02, 0.02, 0.01, 0.01, 0.05, 0.01, 0.01
3	27	3	3.63, 0.1, 0.02	0,1.3, 3.33	3.36, 0.5, 0.07
3	29	3	3.6, 11.54	0, 0.93, -5.56	3.36, 17.1
3	31	2	0.14, 0.14	0	0.05, 0.05
3	32	23	-0.49, -0.34, -0.09, -2.72, -0.03, -0.55, -3.1, -0.63, -0.08, -1.37, -0.73, -0.1, -0.94, -0.47, -1.05, -0.1, -0.52, -5.06, -0.26, - 0.04, -0.08, -0.08, -0.17	No Impact	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0.81, 5.66, 0.98, 2.65, 0.55
4	39	3	0.4, 1.21, 0.31	No Impact	0.29, 1.35, 0.23
4	41	1	1.4	No Impact	2.100
4	42	2	No Impact	1.33, 1.33	No Impact
4	43	3	0.41, 1.13, 0.05	0,0, 5.83	0, 0, 0.28
4	44	9	No Impact	16.1, 6.7, 3.5, 3.5, 25, 3.33, 2.67, 2.67, 11.67	No Impact
5	47	6	13.02, 6.65, 0.1, 0.81, 0.69, 3.08	0,0,0,0,0 25	14.46, 6.1, 0.05, 0.6, 0.64, 2.29
5	48	24	0.1, 1.42, 0.45, 0.46, 0.02, 0.09, 0.11, 0.37,	0,0,0,0,0,0 ,0,0,0,0,0,	0.25, 1.31, 0.17, 0.43, 0.03, 0.06, 0.04, 0.28,

Table 4.9: Frequency of change orders and %impact on performance (contd.)

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC[(1)] impact per each occurrence
5	48	24	0.014, 0.12, 0.07, 0.25, 0.06, 0.4, 003, 0.1, 0.38, 1.02, 0.02, 0.14, 0.19, 5.84, 0.13, 0.31	0,0,0,0,0,0 ,0,0,0,0,0, 0.28, 3.9	0.01, 0.05, 0.03, 0.21, 0.01, 0.17, 0.15, 5.41, 0.05, 0.36, 0.16, 0.07, 0.05, 0.01, 0, 0.01
5	49	11	0.98, 1.26, 0.74, 0.59, 1.12, 1.77, -0.36, 6.1, 1.55, 0.41, 0.1	0,0,0,0,0,0 ,0,0,0, 2.7, 1.25	0.4, 0.93, 0.14, 0.06, 0.42, 0.33, 0, 5.61, 0.58, 0.16, 0.04
6	52	4	-0.57, -0.81, -0.09, -0.28	No Impact	No Impact
6	53	44	0.6, 0.5, 0.73, 0.07, 0.06, 0.35, 0.02, 0.04, 1.14, 0.24, 1.79, 0.08, 1.14, 0.24, 2.68, 3.62, 0.48, 0.81, 0.6, 0.06, 5.62, 1.56, 0.2, 0.05, 0.07, 0.02, 2.36, 0.21, 0.1, 0.01, 0.28, 0.05, 1.96, 0.05, 0.07, 2.28, 2.42, 0.32, 0.06, 1.62, 1.9, 0.15, 0.29, 0.27	No Impact	0.75, 0.46, 0.67, 0.05, 0.05, 0.14, 0, 0.06, 0.05, 0.01, 1, 0.01, 0.05, 0.01, 2.46, 2.69, 036, 2.2, 0.76, 6.8, 0.22, 0.02, 0.01, 2.98, 0.08, 0.04, 0.01, 0.16, 0.02, 0.01, 0.04, 3.28, 0.13, 0, 0, 0, 0, 0, 0, 0, 0.03, 0.06, 0.01
6	54	4	-3.77, -3.06, -3.19, 4.82	0,0,0, 0.37	0, 0, 0, 7.14
7	56	2	2.72, 0	0, -1	No Impact
8	69	1	No Impact	1.48	No Impact
8	71	2	3.12, 0.18	No Impact	1.6, 0.04
8	80	1	0.09	No Impact	No Impact
9	83	1	0.02	No Impact	No Impact
9	85	1	No Impact	0.01	No Impact
9	87	6	1.25, 9.52, 0.11, 0.78, 0.14, 0.62	No Impact	0.03, 1.89, 0.13, 0.73, 0.06, 058

Table 4.9: Frequency of change orders and %impact on performance (contd.)

Group number	Factor number	Occurrences	% Cost impact per each occurrence	% Time impact per each occurrence	% PC[(1)] impact per each occurrence
9	90	30	0.03, 0.3, 0.07, 0.53, 017, 0.21, 0.26, 0.01, 0.05, 0.02, 0.06, 0.04, 0.01, 0.05, 0.02, 0.02, 0.53, 0.16, 0.11, 0.08, 0.06, 0.12, 0.06, 0.02, 012, 0.01, 0.11, 0.65, 0.65, 0.22	No Impact	0.01, 0.22, 0.03, 0.01, 0.19, 0.4, 0.42, 0.01, 0.05, 0.02, 0.05, 0.04, 0.01, 0.05, 0.02, 0.02, 0, 0.15, 0.08, 0.06, 0.05, 0.03, 0.22, 0.01, 0.16, 0.01, 0.1, 0.01, 0.48, 0.04
9	91	2	0, 0.04	0.28, 4.63	0, 0.17
9	95	7	0.38, 1.53, 0.48, 6.89, 1.3, 0.13, 0.6	No Impact	0.08, 1.99, 0.85, 11.25, 1.17, 0.11, 0.52
9	96	6	0.22, 0.1, 0.04, 0.03, 0.03, 0.38	No Impact	0, 0.05, 0.04, 0.01, 0.01, 0.7
10	98	2	0.12, 0.01	No Impact	0.05, 0.04
10	100	5	0.17, 0.15, 0.09, 0.17, 0.13	No Impact	0.084, 0.12, 0.032, 0.48, 0.12

[(1)]Percentage of Change on project in terms of original budgeted work hours

Chapter 5

Analysis and Results

This chapter describes the results obtained from 15 case studies. The Input Analyzer in Arena packages was used to analyze the occurrences of change orders and their impact on cost, time, and productivity to rank the occurrences and the impact of change orders on building projects in the Gaza Strip in health, education, and residential sectors, cited in Al – helou (2006).

5.1 Change Orders Analysis

In this section the groups of change orders are ranked according to their importance for the health, education, and residential building projects, and then for all projects.

5.1.1 Health sector

The most important group producing 44.9 % of change orders in health sector was scope and quantities of work as shown in Table 5.1, followed by the design errors with 27.1 %, and other groups came as secondary groups producing only 28 % of change orders.

Changes in market conditions in the health sector did not have any effect on the construction industry. Figure 5.1 shows the major groups influencing the occurrences of change orders in the health sector.

5.1.2 Education sector

The most important groups producing 32% of change orders in education sector was design errors as shown in Table 5.2, followed by the suggestion to initiate better with 24% of the change orders.

Table 5.1: Rank of importance of group for health buildings

Serial	Group number	Group name	Occurrences	Frequency of occurrences (%)	Rank
1	3	Scope and quantities of work	53	44.9	1
2	1	Design errors	32	27.1	2
3	5	Differing site conditions	8	6.77	3
4	9	Actions by others	8	6.77	3
5	6	Suggestion to initiate better	7	5.93	5
6	4	External conditions	3	2.54	6
7	8	Contract conditions	3	2.54	6
8	10	Final coordination without in contract equipment	3	2.54	6
9	7	Changes in design preference	1	0.85	9
10	2	Changes in market conditions	0	0	10

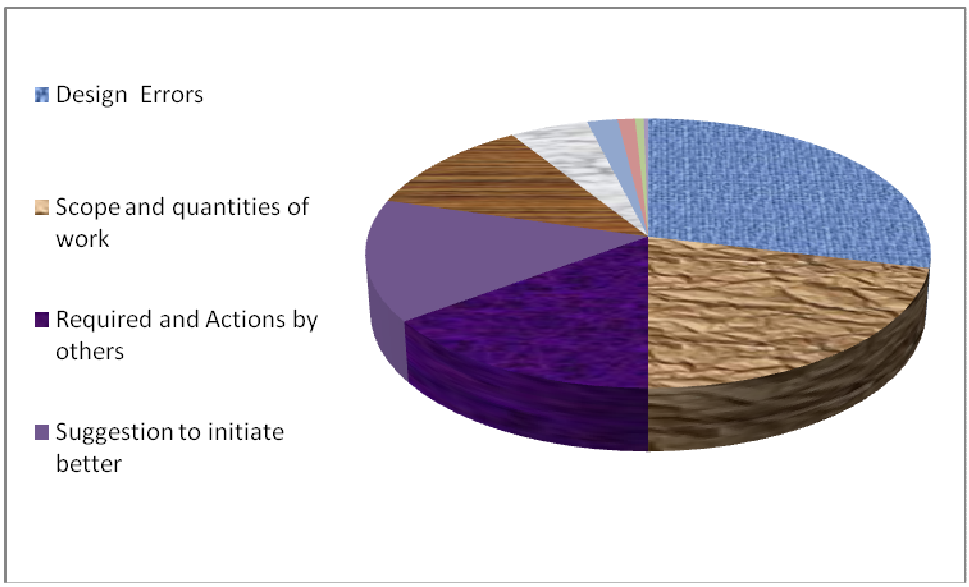


Fig 5.1: Major groups influencing the occurrences of change orders in the Gaza Strip.

Differing site conditions with 13%, scope and quantities of work with 10% , actions by others with 10%, and external conditions with 7% were a minor groups (Figure 5.2).

Changes in market conditions, changes in design preference, final coordination without contract equipment came as secondary groups by producing only 2.22% of change orders.

Contract conditions does not have any effect on the education sector in the construction industry. Figure 5.2 shows the groups influencing the occurrences of change orders in the Gaza Strip in the education sector.

Table 5.2: The rank of important of group education building

#	Group Number	Group Name	Occurrences	Frequency of Occurrences (%)	Rank
1	1	Design errors	44	32	1
2	6	Suggestion to initiate better	33	24	2
3	5	Differing site conditions	18	13	3
4	3	Scope and quantities of work	14	10	4
5	9	Actions by others	14	10	4
6	4	External conditions	10	7	6
7	2	Changes in market conditions	1	0.74	8
8	7	Changes in design preference	1	0.74	8
9	10	Final coordination without in contract equipment	1	0.74	8
10	8	Contract conditions	0	0	10

5.1.3 Residential buildings

The most important group which produces 30.39% of change orders in residential sector was actions by others as shown in Table 5.3, followed by the design errors with 26.47%. Differing site conditions, suggestion to initiate better, and scope and quantities of work came in the middle by causing 33.31% of change orders in the residential sector in the Gaza Strip. Other groups came as secondary group by producing only 7.82% of change orders.

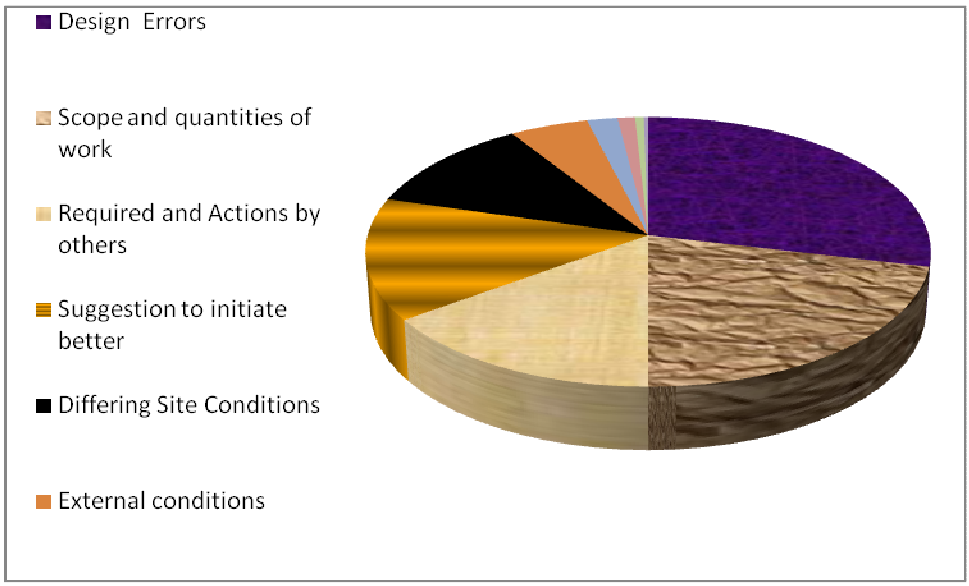


Fig 5.2: Major groups influencing the occurrences of change orders in Gaza Strip.

Changes in market conditions and changes in design preference did not have any effect on the residential sector in the Gaza Strip's construction industry. Figure 5.3 below shows the groups influencing the occurrences of change orders in Gaza strip for residential sector.

Table 5.3: The rank of important of group for residential building

#	Group number	Group Name	Occurrences	Frequency of Occurrences (%)	Rank
4	9	Actions by others	31	30.39	1
2	1	Design errors	27	26.47	2
3	5	Differing site conditions	14	13.73	3
5	6	Suggestion to initiate better	12	11.76	4
1	3	Scope and quantities of work	9	8.82	5
6	4	External conditions	5	4.90	6
8	10	final coordination without in contract equipment	3	2.94	7
7	8	Contract conditions	1	0.98	8
10	2	Changes in market conditions	0	0.00	9
9	7	Changes in gesign preference	0	0.00	10

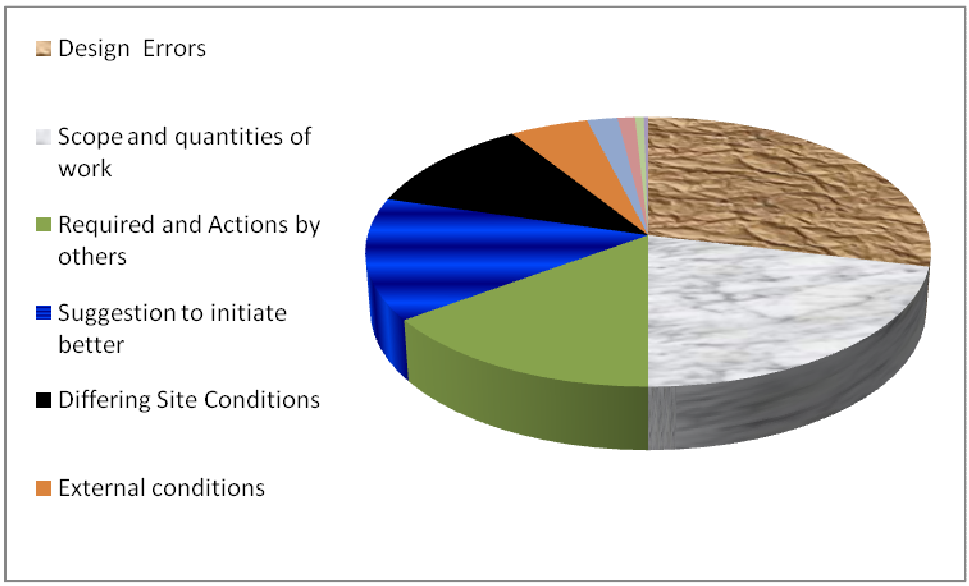


Fig 5.3: Major groups influencing the occurrences of change orders in Gaza Strip.

5.1.4 All sectors

The most important group which produced 28.7% of change orders in building projects was design errors as shown in Table 5.3, followed by scope and quantities of work with 21.3%, actions by others with 14.9, Suggestion to initiate better with 14.6%, Differing site conditions with 11.5%, and External conditions with 5.06%.

Final coordination without in contract equipment, Contract conditions, Changes in Design Preference, and Changes in market conditions did not have any significant effect. Figure 5.4 shows the major groups influencing the occurrences of change orders in the Gaza Strip**.**

5.2 Factors Influencing Change Orders and their Impact for the Health Sector

At this stage the data which were collected from case studies and interviews from the health sector were analyzed collectively to study the reality of change orders and their impact on performance, This data also contained the analysis of occurrences and their impact on performance analysis.

Table 5.4: The rank of importance of groups in all sectors

#	Group Number	Group Name	Occurrences	Frequency of Occurrences (%)	Rank
1	1	Design errors	102	28.8	1
2	3	Scope and quantities of work	75	21.2	2
3	9	Actions by others	53	14.97	3
4	6	Suggestion to initiate better	52	14.68	4
5	5	Differing site conditions	40	11.3	5
6	4	External conditions	18	5.1	6
7	10	Final coordination without in contract equipment	7	1.98	7
8	8	Contract conditions	4	1.13	8
9	7	Changes in design preference	2	0.56	9
10	2	Changes in market conditions	1	0.28	10

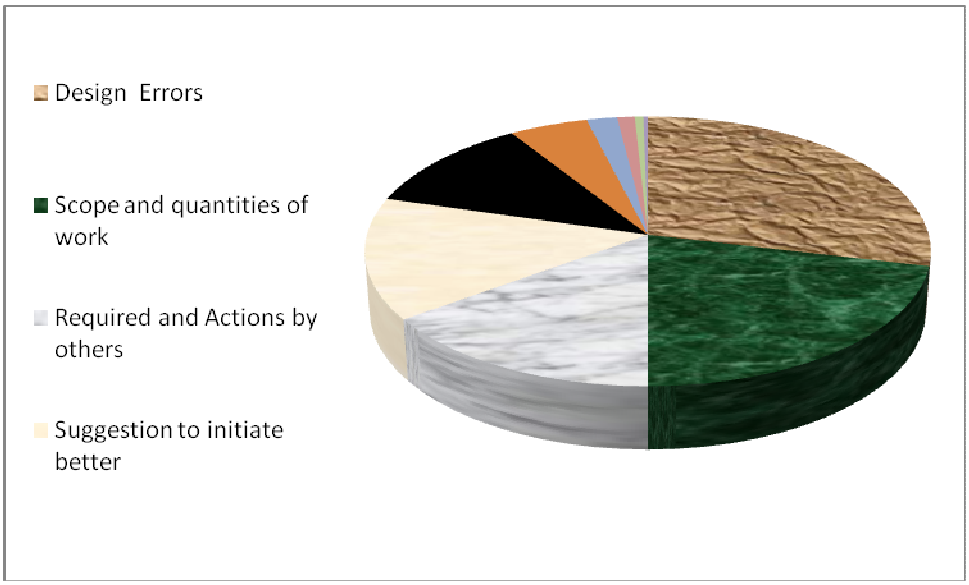


Fig 5.4: Major groups influencing the occurrences of change orders in Gaza Strip.

5.2.1 Major factors influencing the occurrences of change orders

There were only 29 effective factors causing change orders in the health sector in the Gaza Strip. The factors varied among themselves in their strength, where significant changes in the quantities of work were the most effective factor as it

caused 26.65% of the number of change orders. This factor reflected itself strongly in the rehabilitation projects.

Owner desire to improve his financial conditions was a major factor causing 15.83% of the change orders in this sector. This factor began to appear directly after the increase in estimated budget, resulting from the occurrences of change orders.

Inadequate design was the third effective factor as it resulted in 13.33% of the change orders in the health sector. Really, this factor had an awful impact on the Gaza Strip construction industry as it appeared approximately in all projects. Therefore, it must be resolved.

Safety considerations with 5%, suggestions to initiate more quality with 5%, design errors with 4.17%, noncompliance of design with owner's requirements with 4.17%, and prevalent practice on this project and/or district with 2.5% have a middle effect on causing change orders in health sector. Other factors in Table 5.5 were considered as a minor factors

Table 5.5: Factors causing change orders in the health sector

Group	Factor Number	Factor Name	Occurrences	Number of Projects	Frequency of Occurrences (%)	Rank
3	21	Significant changes in the quantities of work	32	3	26.67	1
3	32	Owner desire to improve his financial conditions	19	3	15.83	2
1	8	Inadequate design	16	3	13.33	3
5	48	Safety considerations	6	2	5.00	4
6	53	Suggestions to initiate more quality	6	3	5.00	4
1	1	Design errors	5	2	4.17	6
1	15	Noncompliance of design with owner's requirements	5	3	4.17	6
9	87	A prevalent practice on this project and/or district	3	2	2.50	8

Table 5.5: Factors causing change orders in the health sector (contd.)

Group	Factor Number	Factor Name	Occurrences	Number of Projects	Frequency of Occurrences (%)	Rank
1	4	Inconsistencies	2	1	1.67	9
1	6	Change in design request	2	1	1.67	9
9	90	User needs	2	2	1.67	9
10	100	Technology changes	2	2	1.67	9
4	43	Material non- availability	2	2	1.67	9
5	49	Differing subsurface conditions.	1	1	1.67	9
3	29	Change of plans or scope by owner	1	1	1.67	9
1	2	Omissions	1	1	0.83	16
1	5	Impossibilities.	1	1	0.83	16
3	27	Plan errors	1	1	0.83	16
4	44	Israeli closure	1	1	0.83	16
5	47	Differing site conditions	1	1	0.83	16
6	54	Value engineering	1	1	0.83	16
7	56	Delays in the project	1	1	0.83	16
8	69	Consultant’s lack of judgment and experience	1	1	0.83	16
8	71	Honest wrong beliefs of consultant	1	1	0.83	16
8	80	Contractor’s lack of judgment and experience	1	1	0.83	16
9	85	Local governments	1	1	0.83	16
9	91	Review of the project by the proper governmental agency	1	1	0.83	16
9	96	Socio-cultural factors	1	1	0.83	16
10	98	Mechanical and electrical provision	1	1	0.83	16

5.2.2 Impact of change orders on cost

From the 29 previous factors causing change orders in health sector only 26 factors had an impact on cost, as only three factors reduced the cost while 23 factors increased it.

Change of plans or scope by owner has the greatest impact on cost causing 5.77 % increase in cost with maximum of 11.5%. So one time occurrence of this factor may cause a fatal failure in the project budget. Matters would much more fatal if it happened more than once as is did in one case study. Legally speaking, this factor causes a cardinal change but in the Gaza strip all parties deal with it as a natural change order and that may be due to a misunderstanding of the concept of change orders.

Value engineering in the Gaza Strip health sector appears one time but with a big impact on cost as it caused 4.82% increase in contract value. This change was a sudden, self-imposing one. So the parties concerned took their time in studying it. The owner paid for it out of the contract provisional sum and the contractor used a new crews to execute it so it was fully under control.

A prevalent practice on this project and/or district appeared three times in two projects with a mean of 3.63%, but its maximum appearance was 9.52%, which means it was one of the factors which has a significant impacts on the Gaza Strip health sector.

Differing site conditions and delays in the projects had a great impact on cost, where they increased the contract value by 3.08% and 2.72%. The former can be controlled by site inspectation, while the delays in the projects leaded to direct acceleration in the health projects.

Other factors had unessential impact but their great problem was their intensity, which may have led to project failure.

Omissions, change in design request, and owner desire to improve his financial conditions had decreasing impact on cost but without an effective mean. The first two factors took place according to the specialty of the projects so there were not any side effects but owner's desire to improve his financial conditions resulted in the owner decreasing the estimated cost so it had a bad impact on other performance factors.

Table 5.6: The impact of change orders on cost in the health sector

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
3	29	Change of plans or scope by owner	0	11.5	5.77	8.2	1
6	54	Value engineering	4.82	4.82	4.82	0	2
9	87	A prevalent practice on this project and/or district.	0.11	9.52	3.63	5.1	3
5	47	Differing site conditions	3.08	3.08	3.08	0	4
7	56	Delays in the project	2.72	2.72	2.72	0	5
1	15	Noncompliance of design with owner's requirements	0.04	4.84	1.66	1.9	6
1	5	Impossibilities	1.37	1.37	1.37	0	7
4	43	Material non- availability	0.41	1.13	0.77	0.5	8
6	53	Suggestions to initiate more quality	0.06	1.9	0.715	0.8	9
9	90	User needs	0.22	0.65	0.435	0.3	10
1	8	Inadequate design	0.01	3.1	0.42	0.8	11
9	96	Socio-cultural factors	0.38	0.38	0.38	0	12
5	48	Safety considerations	0.03	1.02	0.332	0.4	13
3	21	Significant changes in the quantities of work	-0.41	2.25	0.31	0.5	14
1	1	Design errors	0.06	0.57	0.26	0.2	15
5	49	Differing subsurface conditions.	0.10	0.41	0.255	0.2	16
8	71	Honest wrong beliefs of consultant	0.18	0.18	0.18	0	17
10	100	Technology changes	0.13	0.17	0.15	0.0	18
3	27	Plan errors	0.1	0.1	0.1	0	19
1	4	Inconsistencies	0.08	0.1	0.09	0.0	20
8	80	Contractor's lack of judgment and experience	0.09	0.09	0.09	0	20

Table 5.6: The impact of change orders on cost in the health sector (contd.)

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
9	91	Review of the project by the proper governmental agency	0.04	0.04	0.04	0	22
10	98	Mechanical and electrical provision	0.01	0.01	0.01	0	23
1	2	Omissions	-0.16	-0.16	-0.16	0	24
1	6	Change in design request	-3.43	2.89	-0.27	4.5	25
3	32	Owner desire to improve his financial conditions	-5.06	0.04	-0.94	1.3	26

5.2.3 Impact of change orders on time

From the 29 factors causing change orders in the Gaza Strip health sector only 8 factors caused an extension in the contract schedule. The most effective factor was the Israelis closures with a mean of 11.7 % of impact on time for every occurrence. Thus, problems from this factor must be resolved effectively.

Review of the project by the proper governmental agency had a mean of 4.63% impact on time. Due to the importance of the health sector, many techniques should be used to end this delay. Material unavailability caused 2.92% impact on time.

Consultant’s lack of judgment and experience caused 1.48% extension of time despite the importance of the health sector.

Plan errors, value engineering, change of plans or scope by owner, and local governments also led to time extension but without real effective impact on time and project manager can control their impact if he has good experience.

Table 5.7: The impact of change orders on time in health sector

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
4	44	Israeli closure	11.67	11.7	11.67	0	1
9	91	Review of the project by the proper governmental agency	4.63	4.63	4.63	0	2
4	43	Material non- availability.	0	5.83	2.92	4.1	3
8	69	Consultant's lack of judgment and experience.	1.48	1.48	1.48	0	4
3	27	Plan errors	1.3	1.3	1.3	0	5
6	54	Value engineering	0.37	0.37	0.37	0	6
3	29	Change of plans or scope by owner	0	0.93	0.31	0.5	7
9	85	Local governments	0.01	0.01	0.01	0	8

5.2.4 Impact of health sector change orders on productivity

There were 23 factors that had an impact on the percentage of change on project in terms of original budgeted work hours, which means direct impact on productivity where all factors in one project were constant so the variable was only the percentage of change on project in terms of original budgeted work hours.

Change of plans or scope by owner and value engineering were the most effective factors which led to productivity losses. Differing site conditions and noncompliance of design with owner's requirements came in the second level in causing productivity losses and the other factors came as minor factors. On the other hand, the intensity of the factors had the greatest impact and it may have led to productivity fatigue.

Table 5.8: The impact of change orders on productivity in health sector

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
3	29	Change of plans or scope by owner	0	17.1	8.55	12	1
6	54	Value engineering	7.14	7.14	7.14	0	2

Table 5.8: The impact of change orders on productivity in health sector (contd.)

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
5	47	Differing site conditions	2.29	2.29	2.29	0	3
1	15	Noncompliance of design with owner's requirements	0.07	4.19	1.11	1.8	4
9	96	Socio-cultural factors	0.7	0.7	0.7	0	5
1	8	Inadequate design	0	5.44	0.683	1.5	6
9	87	A prevalent practice on this project and/or district	0.03	1.89	0.683	1.1	7
3	21	Significant changes in the quantities of work	0	12.7	0.627	2.3	8
3	32	Owner desire to improve his financial conditions.	0	5.66	0.561	1.4	9
3	27	Plan errors	0.5	0.5	0.5	0	10
10	100	Technology changes	0.12	0.48	0.3	0.3	11
1	5	Impossibilities.	0.26	0.26	0.26	0	12
9	90	User needs	0.04	0.48	0.26	0.3	13
1	1	Design errors	0.01	0.6	0.198	0.2	14
9	91	Review of the project by the proper governmental agency	0.17	0.17	0.17	0	15
1	6	Change in design request	0.04	0.24	0.14	0.1	16
4	43	Material non- availability	0	0.28	0.14	0.2	17
5	49	Differing subsurface conditions	0.04	0.16	0.1	0.1	18
1	4	Inconsistencies	0.04	0.15	0.095	0.1	19
5	48	Safety considerations	0	0.16	0.05	0.1	20
8	71	Honest wrong beliefs of consultant	0.04	0.04	0.04	0	21
10	98	Mechanical and electrical provision	0.04	0.04	0.04	0	22
6	53	Suggestions to initiate more quality	0	0.06	0.017	0.0	23

5.3 Factors Influencing Change Orders and their Impact for the Education Sector

The data which were collected from case studies and interviews were analyzed collectively to study the reality of change orders and their impact on performance. Following are the results of such an analysis.

5.3.1 Major factors influencing the occurrences of change orders

Twenty three factors hit the education building projects to cause change orders in the Gaza Strip. The most effective factors in this sector were inadequate design which accounted for 25.19% of the change orders' occurrence, then suggestions to initiate more quality with 22.22%. These two factors had a dangerous intensity and were evident in approximately all the education projects.

Significant changes in the quantities of work, design errors, differing subsurface conditions, user needs, safety considerations, differing site conditions, Israeli closures, and socio-cultural factors caused numerous change orders in the education sector are they caused 36.3% of the change orders.

Other factors in Table 5.9 came as secondary ones they accounted for only 17.02% of change orders in this sector.

Table 5.9: Factors causing change orders in education sector

Group	Factor Number	Factor Name	Occurrences	Number of Projects	Frequency of Occurrences (%)	Rank
1	8	Inadequate design	34	5	25.19	1
6	53	Suggestions to initiate more quality	30	6	22.22	2
3	21	Significant changes in the quantities of work	9	2	6.67	3
1	1	Design errors	7	4	5.19	5
5	49	Differing subsurface conditions	7	3	5.19	5
9	90	User needs	7	4	5.19	5

Table 5.9: Factors causing change orders in education sector (contd.)

Group	Factor Number	Factor Name	Occurrences	Number of Projects	Frequency of Occurrences (%)	Rank
5	48	Safety considerations	6	5	4.44	7
5	47	Differing site conditions	5	2	3.70	8
4	44	Israeli closure	4	4	2.96	9
9	96	Socio-cultural factors	4	3	2.96	9
4	39	Uncovering disclosed existing conditions	3	1	2.22	11
6	52	Suggestions to initiate more economical construction	3	1	2.22	11
9	87	A prevalent practice on this project and/or district	3	2	2.22	11
1	4	Inconsistencies	2	2	1.48	14
3	31	Change in the owner's requirements	2	2	1.48	14
4	42	Extreme whether condition	2	2	1.48	14
3	32	Owner desire to improve his financial conditions	2	1	1.48	14
1	5	Impossibilities	1	1	0.74	18
2	18	Specified item became unavailable	1	1	0.74	18
3	27	Plan errors	1	1	0.74	18
4	43	Material non- availability	1	1	0.74	18
7	56	Delays in the project	1	1	0.74	18
10	98	Mechanical and electrical provision	1	1	0.74	18

5.3.2 Impact of change orders on cost

Of the 23 previous factors which caused change orders in the Gaza Strip in the education sector, only 20 factors had an impact on cost. Only two of those factors decreased the cost while 18 of them increased it.

Differing site conditions had the greatest impact on cost and accounted for 4.25 % of cost increase with maximum of 13% . The cause of this change in education sectors can be attributed to weak site visit.

Differing subsurface conditions was the second effective factor as it accounted for 1.75% increase in contract value, but sometimes it may have resulted in 6.1% cost increase.

Safety considerations played an important role in the education sector where the health of our children is the most important consideration.. The mean of this factor was 1.1% but the maximum was 5.84%, so sometimes it had big impact.

Suggestions to initiate more quality played a big role in increasing contracts value accounting for 1.1% of cost increase, but the average of its concurrency was 5 times in every project where the mean of its occurrence was 5.5 in every contract value in the Gaza Strip education sector.

Uncovering disclosed existing conditions, specified item became unavailable, a prevalent practice on this project and/or district, significant changes in the quantities of work, inadequate design, change in the owner's requirements, mechanical and electrical provision, impossibilities, user needs, design errors, material unavailability, socio-cultural factors, and plan errors came as a secondary factors.

Suggestions to initiate more economical construction and owner desire to improve his financial conditions were used in education projects in large numbers in trying to control cost increase.

Table 5.10: The impact of change orders on cost in education sector

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
5	47	Differing site conditions	0.1	13	4.25	5.6	1
5	49	Differing subsurface conditions	0.36	6.1	1.75	2	2
5	48	Safety considerations	0.02	5.84	1.1	2.3	3

Table 5.10: The impact of change orders on cost in education sector (contd.)

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
6	53	Suggestions to initiate more quality	0.01	5.62	1.02	1.3	4
4	39	Uncovering disclosed existing conditions	0.31	1.21	0.64	0.5	5
2	18	Specified item became unavailable	0.63	0.63	0.63	0	6
9	87	A prevalent practice on this project and/or district	0.14	0.78	0.513	0.3	7
3	21	Significant changes in the quantities of work	-1.34	0.96	0.308	0.	8
1	8	Inadequate design	0.01	0.7	0.231	0.2	9
1	4	Inconsistencies	0.02	0.29	0.155	0.2	10
3	31	Change in the owner's requirements	0.14	0.14	0.14	0	11
10	98	Mechanical and electrical provision	0.12	0.12	0.12	0	12
1	5	Impossibilities	0.08	0.08	0.08	0	13
9	90	User needs	0.01	0.12	0.072	0.1	14
1	1	Design errors	0.01	0.13	0.051	0.0	15
4	43	Material non- availability	0.05	0.05	0.05	0	16
9	96	Socio-cultural factors	0.03	0.1	0.05	0.0	16
3	27	Plan errors	0.02	0.02	0.02	0	18
3	32	Owner desire to improve his financial conditions	-0.17	-0.04	-0.105	0.1	19
6	52	Suggestions to initiate more economical construction	-0.81	-0.09	-0.393	0.4	20

5.3.3 Impact of change orders on time

Israeli closure was the most effective factor causing delay in education projects as it accounted for 8.42% in average extension time followed by differing site conditions which caused 5% and plan errors which caused 3.33% of time increase. Last came extreme weather conditions which resulted in 1.33% delay. The remaining factors did not play any role in delay in education projects.

Table 5.11: The impact of change orders on time in education sector

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
4	44	Israeli closure	2.67	25	8.42	11.1	1
5	47	Differing site conditions	0	25	5	11.2	2
3	27	Plan errors	3.33	3.33	3.33	0	3
4	42	Extreme whether condition	1.33	1.33	1.33	0	4

5.3.4 Impact of change orders on productivity

Seventeen factors had direct impact on productivity. Productivity can be calculated by taking the percentage of change on project in terms of original budgeted work hours as the main variable so differing site conditions, safety considerations, and differing subsurface conditions were the main factors which caused productivity loss.

Suggestions to initiate more quality, uncovering disclosed existing conditions, significant changes in the quantities of work, a prevalent practice on this project and/or district, inconsistencies, had a middle impact on education sectors the other factor did not have an essential role.

Table 5.12: The impact of change orders on productivity in the education sector

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
5	47	Differing site conditions	0.05	14.5	4.37	6.2	1
5	48	Safety considerations	0.01	5.41	1.03	2.2	2
5	49	Differing subsurface conditions	0	5.61	1.02	2.0	3

Table 5.12: The impact of change orders on productivity in the education sector (contd.)

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
6	53	Suggestions to initiate more quality	0	6.1	0.817	1.4	4
4	39	Uncovering disclosed existing conditions	0.23	1.35	0.623	0.6	5
3	21	Significant changes in the quantities of work	0	1.69	0.551	0.6	6
9	87	A prevalent practice on this project and/or district	0.06	0.73	0.457	0.4	7
1	4	Inconsistencies	0.08	0.32	0.2	0.2	8
1	8	Inadequate design	0.01	0.41	0.138	0.1	9
9	90	User needs	0.01	0.22	0.077	0.1	10
3	27	Plan errors	0.07	0.07	0.07	0	11
2	18	Specified item became unavailable	0.6	0.06	0.06	0	12
3	31	Change in the owner's requirements	0.05	0.05	0.05	0	13
10	98	Mechanical and electrical provision	0.05	0.05	0.05	0	13
1	1	Design errors	0.01	0.11	0.031	0.0	15
9	96	Socio-cultural factors	0.01	0.05	0.026	0.0	16
1	5	Impossibilities	0.02	0.02	0.02	0	17

5.4 Factors Influencing Change Orders and their Impact for the Residential Sector

In the following sections, the data collected from the case studies and interviews in the residential sector will be analyzed so as to reveal the reality of change orders

and their impact on performance. These sections will also entail the occurrence analysis and the impact of those occurrences on the performance analysis.

5.4.1 Major factors influencing the occurrences of change orders

Twenty two effective factors caused change orders in Gaza Strip residential sector where inadequate design and user needs played an essential role resulting in 20.59% occurrences of change orders per each factor. This means that about 50% of the change orders in residential sector caused by the two previous factors.

Change orders factors vary among themselves in their strength where significant changes in the quantities of work was the most effective factor resulting in 26.65% of the number of change orders in health sector. These factors reflected themselves strongly in a big number of health rehabilitation projects.

Safety considerations with 11.76%, suggestions to initiate more quality with 7.84%, and change in economic conditions with 6.86%, came second in causing change orders in the Gaza Strip residential sector.

Significant changes in the quantities of work, Israeli closure, inconsistencies, owner desire to improve his financial conditions, value engineering, technology changes, design errors, and differing subsurface conditions came as secondary factors accounting for 22.98% of the total change orders.

Factors such as impossibilities, plan errors, socio-cultural factors, strikes, suggestions to initiate more economical construction, honest wrong beliefs of consultant, utility companies, review of the project by the proper governmental agency, and change of plans or scope by owner each occurred only one time in all cases, so despite their occurrence in the Gaza Strip residential sector, they did not have any importance in change orders.

Table 5.13: Factors causing change orders in residential sector

Group	Factor Number	Factor Name	Occurrences	Number of Projects	Frequency of Occurrences (%)	Rank
1	8	Inadequate Design	21	4	20.59	1
9	90	User needs	21	4	20.59	1

Table 5.13: Factors causing change orders in residential sector (contd.)

Group	Factor Number	Factor Name	Occurrences	Number of Projects	Frequency of Occurrences (%)	Rank
5	48	Safety considerations	12	5	11.76	3
6	53	Suggestions to initiate more quality	8	4	7.84	4
9	95	Change in economic conditions	7	2	6.86	5
3	21	Significant changes in the quantities of work	4	1	3.92	6
4	44	Israeli closure	4	3	3.92	6
1	4	Inconsistencies	3	2	2.94	8
3	32	Owner desire to improve his financial conditions	3	1	2.94	8
6	54	Value engineering	3	3	2.94	8
10	100	Technology changes	3	1	2.94	8
1	1	Design errors	2	2	1.96	12
5	49	Differing subsurface conditions	2	2	1.96	12
1	5	Impossibilities	1	1	0.98	14
3	27	Plan errors	1	1	0.98	15
3	29	Change of plans or scope by owner	1	1	0.98	15
4	41	Strikes	1	1	0.98	15
6	52	Suggestions to initiate more economical construction	1	1	0.98	15
8	71	Honest wrong beliefs of consultant	1	1	0.98039	15
9	83	Utility companies	1	1	0.98	15
9	91	Review of the project by the proper governmental agency	1	1	0.98	15
9	96	Socio-cultural factors	1	1	0.98	15

5.4.2 Impact of change orders on cost

Plans error resulted in 3.63 of contract value increase, change of plans or scope by owner resulted in 3.6 of increase in contract value, and honest wrong beliefs

of consultant resulted in 3.12 of increase in contract value> this last factor, as it can be noticed, was the most effective factor having an enormous impact on cost. The good thing is that every factor of those illustrated above occurred only one time in this sector. Nonetheless, their impact on cost needs to be controlled.

Change in economic conditions, strikes, and differing subsurface conditions came second in increasing contract value.

The secondary factors which have cost impact in this sector were suggestions to initiate more quality, safety considerations, socio-cultural factors, inadequate design, technology changes, utility companies, design errors, impossibilities, user needs, inconsistencies, and significant changes in the quantities of work.

Owner desire to improve his financial conditions and suggestions to initiate more economical construction were used to reduce contract value but they did not have a big impact.

Value engineering occurred three times in three different projects causing decreasing in contract value by 3.34%, so it must be encouraged.

Table 5.14: The impact of change orders on cost in the residential sector

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
3	27	Plan errors	3.63	3.63	3.63	0	1
3	29	Change of plans or scope by owner	3.60	3.6	3.6	0	2
8	71	Honest wrong beliefs of consultant	3.12	3.12	3.12	0	3
9	95	Change in economic conditions	0.13	6.89	1.62	2.2	4
4	41	Strikes	1.40	1.4	1.400		5
5	49	Differing subsurface conditions	0.98	1.26	1.12	0.2	6
6	53	Suggestions to initiate more quality	0.02	0.73	0.296	0.3	7
5	48	Safety considerations	0.02	1.42	0.289	0.4	8
9	96	Socio-cultural factors	0.22	0.22	0.22	0	9
1	8	Inadequate design	0.02	1.42	0.207	0.3	10

Table 5.14: The impact of change orders on cost in the residential sector (contd.)

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
10	100	Technology changes	0.09	0.17	0.137	0.0	11
3	21	Significant changes in the quantities of work	0.02	0.34	0.113	0.2	12
1	1	Design errors	0.02	0.2	0.11	0.1	13
1	5	Impossibilities	0.09	0.09	0.09	0	14
9	90	User needs	-0.5	0.53	0.082	0.2	15
1	4	Inconsistencies	0.00	0.05	0.027	0.0	16
9	83	Utility companies	0.02	0.02	0.02	0	17
3	32	Owner desire to improve his financial conditions	-0.49	-0.09	-0.307	0.2	18
6	52	Suggestions to initiate more economical construction	-0.57	-0.57	-0.57		19
6	54	Value engineering	-3.1	-3.8	-3.34	0.4	20

5.4.3 Impact of change orders on time

Israeli closure was the most effective factor causing delay in education projects resulting in 7.45% in average extension time followed by differing subsurface conditions which accounted for 2.01%, followed by safety consideration resulting in 0.348% increase in time. Last came review of the project by proper governmental agency which accounted for 1.33% delay. Other factors did not play any role in causing delay in the education projects.

Table 5.15: The impact of change orders on time in residential sector

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
4	44	Israeli closure	3.5	16.1	7.45	6	1
5	49	Differing subsurface conditions	1.25	2.78	2.01	1.1	2
5	48	Safety considerations	0	3.9	0.35	1.1	3

Table 5.15: The impact of change orders on time in residential sector (contd.)

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
9	91	Review of the project by the proper governmental agency	0.28	0.28	0.28	0	4

5.4.4 Impact of change orders on productivity

Fourteen factors had direct impact on productivity when taking the percentage of change on project in terms of original budgeted work hours as the main variable together with plan errors, change in economic conditions, change in economic conditions, strikes, honest wrong beliefs of consultant.

Differing subsurface conditions, suggestions to initiate more quality, safety considerations, inadequate design, design errors, significant changes in the quantities of work, user needs, inconsistencies, and technology changes had a moderate impact on education sector whereas the other factor did not have an essential role.

Table 5.16: The impact of change orders on productivity in residential sector

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
3	27	Plan errors	3.36	3.36	3.36	0	1
3	29	Change of plans or scope by owner	3.36	3.36	3.36	0	1
9	95	Change in economic conditions	0.08	11.3	2.28	4.0	3
4	41	Strikes	2.1	2.1	2.10	0	4
8	71	Honest wrong beliefs of consultant	1.6	1.6	1.6	0	5
5	49	Differing subsurface conditions	0.4	0.93	0.67	0.4	6
6	53	Suggestions to initiate more quality	0.05	0.75	0.27	0.3	7
5	48	Safety considerations	0.01	1.31	0.24	0.4	8
1	8	Inadequate Design	0.01	1.31	0.16	0.3	9
1	1	Design errors	0.01	0.22	0.12	0.1	10

Table 5.16: The impact of change orders on productivity in residential sector (contd.)

Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
3	21	Significant changes in the quantities of work	0.01	0.37	0.11	0.2	11
9	90	User needs	0	0.42	0.09	0.1	12
10	100	Technology changes	0.03	0.12	0.08	0.1	13
1	4	Inconsistencies	0.02	0.1	0.04	0.1	14

5.5 Factors Influencing Change Orders and their Impact for the Gaza Strip Building Industry

In the section that follow, the data collected from case studies and interviews people involved in building projects in the Gaza Strip will be analyzed to study the reality of change orders and their impact on performance. The sections will also include the occurrence analysis and impact of each effective factor on performance analysis.

5.5.1 Major factors influencing the occurrences of change orders

There were 37 factors causing change orders in the Gaza Strip. Those factors varied in their strength where inadequate design was the most effective factor causing 19.72% of change orders occurrences in 80% of building projects in the Gaza Strip.

Significant changes in the quantities of work was the second factor in causing change orders by causing 12.68% of change orders occurrences in 40% of building projects in the Gaza Strip. This factor appears strongly intensity in rehabilitation projects.

Suggestions to initiate more quality resulted in 12.68% of change orders in the Gaza Strip in 86% of projects. The occurrence of this factor is due to the fact that there is no specific quality system in the Gaza Strip institutes.

User needs resulted in 8.45% of the occurrences of change orders and it reflected itself strongly in the residential sector.

Safety considerations resulted in 6.76% of change order occurrences and in 80% of the Gaza Strip projects this factor appears strongly in building projects in the

Gaza Strip because there was no significant legal conditions for enforcing safety in construction projects.

Owner desire to improve his financial conditions caused 6.48% of change order occurrences in the Gaza Strip. This Factor appeared strongly after increasing the contract value during numbers of change orders and resulted in their reduction.

Design errors, differing subsurface conditions, Israeli closures, inconsistencies, change in economic conditions, differing site conditions, a prevalent practice on this project and/or district, socio-cultural factors, noncompliance of design with owner's requirements, and technology changes got middle ranking.

Table 5.17 shows every factor causing any change order in fifteen building projects and its rank in the Gaza strip.

Table 5.17: Factors causing change orders

Serial	Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Rank
1	1	8	Inadequate design	70	12	19.72	1
2	3	21	Significant changes in the quantities of work	45	6	12.68	2
3	6	53	Suggestions to Initiate more Quality	44	13	12.39	3
4	9	90	User needs	30	10	8.45	4
5	5	48	Safety considerations	24	12	6.76	5
6	3	32	Owner desire to improve his financial conditions	23	5	6.48	6
7	1	1	Design errors	14	8	3.94	7
8	5	49	Differing subsurface conditions	11	6	3.10	8
9	4	44	Israeli closure	9	8	2.54	9
10	1	4	Inconsistencies	7	5	1.97	10
11	9	95	Change in economic conditions	7	2	1.97	10
12	5	47	Differing site conditions	6	3	1.69	12
13	9	87	A prevalent practice on this project and/or district	6	4	1.69	12
14	9	96	Socio-cultural factors	6	5	1.69	14

Table 5.17: Factors causing change orders (contd.)

Serial	Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Rank
15	1	15	Noncompliance of design with owner's requirements	5	3	1.41	15
16	10	100	Technology changes	5	3	1.41	15
17	6	52	Suggestions to Initiate more economical construction	4	2	1.13	17
18	6	54	Value engineering	4	4	1.13	17
19	1	5	Impossibilities	3	3	0.85	19
20	3	27	Plan errors	3	3	0.85	19
21	4	39	Uncovering disclosed existing conditions	3	1	0.85	19
22	4	43	Material non- availability	3	3	0.85	19
23	1	6	Change in design request	2	2	0.56	23
24	3	29	Change of plans or scope by owner	2	2	0.56	24
25	3	31	Change in the owner's requirements	2	2	0.56	24
26	4	42	Extreme whether condition	2	2	0.56	24
27	7	56	Delays in the Project	2	2	0.56	24
28	8	71	Honest wrong beliefs of consultant	2	2	0.56	24
29	9	91	Review of the project by the proper governmental agency	2	2	0.56	24
30	10	98	Mechanical and electrical provision	2	2	0.56	24
31	1	2	Omissions	1	1	0.28	31
32	2	18	Specified item became unavailable	1	1	0.28	31
33	4	41	Strikes	1	1	0.28	31
34	8	69	Consultant's lack of judgment and experience	1	1	0.28	31
35	8	80	Contractor's lack of judgment and experience	1	1	0.28	31
36	9	83	Utility companies	1	1	0.28	31
37	9	85	Local governments	1	1	0.28	31

5.5.2 Impact of change orders on cost

Although change of plans or scope by owner is considered as a cardinal change, it is dealt with in the Gaza Strip as a constructive change. Therefore, it is sure that it had the greatest impact on cost and consequently increased the contract value by 7.55% in average.

Value engineering was the second factor as it increased the contract value by 4.82% . However, this is a fully controlled factor because the owner paid for it from the provisional sum or maybe he paid for it out of the contact money. On other occasion this same factor decreased the cost by -3.34%.

Differing site conditions had a bad impact on cost as it increased the contract value by 4.06%. The main reason for its occurrences was poor site visit.

Although change in design request increased the cost by 2.89% or decreased it by -3.43% it could be hardly controlled.

Delays in the project caused 2.72% increase in contract value. This cost went up as a result f the overtime work which contractors may have resorted to while trying to meet the project's deadline.

A prevalent practice on this project and/or district appeared strongly in health sector because the inexperience of the designers is a prevalent practice in this sector.

Noncompliance of design with owner’s requirements, change in economic conditions, strikes, plan errors, suggestions to initiate more quality, uncovering disclosed existing conditions, specified item became unavailable, material non-availability, and impossibilities had a moderate impact on cost as shown in Table 5.18.

Owner desire to improve his financial conditions and suggestions to initiate more economical construction were used to reduce contract value but they did not have a significant impact.

Table 5.18: The impact of change orders on cost

Serial	Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
1	3	29	Change of plans or scope by owner	3.6	11.5	7.55	5.6	1

Table 5.18: The impact of change orders on cost (contd.)

Serial	Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
2	6	54	Value engineering	4.82	4.82	4.82	0	2
3	5	47	Differing site conditions	0.36	13	4.06	5.0	3
4	1	6	Change in design request	2.89	2.89	2.89	0	4
5	7	56	Delays in the Project	0	2.72	2.72	1.4	5
6	9	87	A prevalent practice on this project and/or district	0.11	9.52	2.07	3.7	6
7	1	15	Noncompliance of design with owner's requirements	0.04	4.84	1.66	1.9	7
8	8	71	Honest wrong beliefs of consultant	0.18	3.12	1.65	2.1	8
9	9	95	Change in economic conditions	0.13	1.53	1.62	2.4	9
10	5	49	Differing subsurface conditions	0.1	6.1	1.5	1.7	10
11	4	41	Strikes	1.4	1.4	1.4	0	11
12	3	27	Plan errors	0.02	3.63	1.25	2.1	12
13	6	53	Suggestions to Initiate more Quality	0.01	5.62	0.85	1.2	13
14	4	39	Uncovering disclosed existing conditions	0.31	1.21	0.64	0.5	14
15	2	18	Specified item became unavailable	0.63	0.63	0.63	0	15
16	4	43	Material non- availability	0.05	1.13	0.53	0.6	16
17	1	5	Impossibilities	0.08	0.14	0.51	0.7	17
18	5	48	Safety considerations	0.014	5.84	0.50	1.2	18
19	3	21	Significant changes in the quantities of work	0.02	2.25	0.39	0.4	19
20	1	8	Inadequate design	0.01	3.1	0.28	0.5	20
21	10	100	Technology changes	0.09	0.17	0.14	0.0	21

Table 5.18: The impact of change orders on cost (contd.)

Serial	Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
22	3	31	Change in the owner's requirements	0.14	0.14	0.14	0	22
23	1	1	Design errors	0.01	0.57	0.14	0.2	23
24	9	96	Socio-cultural factors	0.03	0.38	0.13	0.1	24
25	9	90	User needs	-0.53	0.65	0.12	0.2	25
26	8	80	Contractor’s lack of judgment and experience	0.09	0.09	0.09	0	26
27	1	4	Inconsistencies	0	0.29	0.08	0.1	27
28	10	98	Mechanical and electrical provision	0.01	0.12	0.07	0.1	28
29	9	83	Utility companies	0.02	0.02	0.02	0	29.5
30	9	91	Review of the project by the proper governmental agency	0	0.04	0.02	0.0	29.5
31	1	2	Omissions	-0.16	-0.16	-0.16	0	31
32	3	21	Significant changes in the quantities of work	-1.34	-0.06	-0.35	0.5	32
33	6	52	Suggestions to Initiate more economical construction	-0.09	-0.81	-0.44	0.3	33
34	3	32	Owner desire to improve his financial conditions	-0.03	-5.06	-0.79	1.2	34
35	6	54	Value engineering	-3.77	-3.06	-3.34	0.4	35
36	1	6	Change in design request	-3.43	-3.43	-3.43	0	36
			Total (+)	15.16	87.46	38.47		
			Total (-)	-9.35	-12.58	-8.51		
			Total	5.81	74.88	29.96		

5.5.3 Impact of change orders on time

Israeli closure imposed on the Palestinian territories was the most effective factor causing delay in education projects as it caused 8.35% in average time extension, followed by differing subsurface conditions which caused 5%, dovetailed by review of the project by the proper governmental agency which resulted in 2.46% increase in time, followed finally by material un availability which caused 1.94% delay.

Other factors were secondary ones they may have resulted in one or two days' delay as shown in Table 5.19.

Table 5.19: The impact of change orders on time

Serial	Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
1	4	44	Israeli closure	2.67	25	8.35	7.8	1
2	5	47	Differing site conditions	0	25	5	11	2
3	9	91	Review of the project by the proper governmental agency	0.28	4.63	2.46	3.1	3
4	4	43	Material unavailability	0	5.83	1.94	3.4	4
5	3	27	Plan errors	0.39	3.33	1.54	1.7	5
6	8	69	Consultant’s lack of judgment and experience	1.48	1.48	1.48	0	6
7	4	42	Extreme whether condition	1.33	1.33	1.33	0	7
8	3	29	Change of plans or scope by owner	0	0.93	0.47	0.7	8
9	5	49	Differing subsurface conditions	0	2.78	0.40	0.9	9
10	6	54	Value engineering	0.37	0.37	0.37	0	10
11	5	48	Safety considerations	0	3.9	0.17	0.8	11

5.5.4 Impact of change orders on productivity

Twenty eight factors had a direct impact on productivity which is calculated by taking the percentage of change on project in terms of original budgeted work hours as the main variable so change of plans or scope by owner have the greatest

impact then a prevalent practice on this project and/or district, after that value engineering and so as shown in Table 5.20.

As seen in literature review, there were other factors playing important role in causing productivity loss as shown in (Equation 2.5).

Table 5.20: Impact of change orders on productivity

Serial	Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
1	3	29	Change of plans or scope by owner	0	17.1	10.2	9.7	1
2	9	87	A prevalent practice on this project and/or district	0.03	1.89	10.1	23	2
3	6	54	Value engineering	7.14	7.14	7.14	0	3
4	5	47	Differing site conditions	0.67	14.5	4.02	5.6	4
5	9	95	Change in economic conditions	0.08	11.3	2.28	4.0	5
6	4	41	Strikes	2.1	2.1	2.10	0	6
7	3	27	Plan errors	0.12	3.36	1.31	1.8	7
8	1	15	Noncompliance of design with owner's requirements	0.07	4.19	1.11	1.8	8
9	5	48	Safety considerations	0	5.41	0.87	1.7	9
10	8	71	Honest wrong beliefs of consultant	0.04	1.6	0.82	1.1	10
11	5	49	Differing subsurface conditions	0	5.61	0.79	1.6	11
12	3	21	Significant changes in the quantities of work	0	12.7	0.65	2.1	12
13	4	39	Uncovering disclosed existing conditions	0.23	1.35	0.62	0.6	13
14	6	53	Suggestions to initiate more quality	0	6.1	0.61	1.2	14
15	3	32	Owner desire to improve his financial conditions	0	5.66	0.46	1.3	15
16	1	8	Inadequate design	0	5.44	0.27	0.8	16

Table 5.20: Impact of change orders on productivity (contd.)

Serial	Group Number	Factor Number	Factor Name	Min (%)	Max (%)	Mean (%)	Std	Rank
17	1	6	Change in design request	0.24	0.24	0.24	0	17
18	10	100	Technology changes	0.03	0.48	0.17	0.2	18
19	9	96	Socio-cultural factors	0	0.7	0.14	0.3	19
20	1	1	Design errors	0.01	0.6	0.10	0.2	20
21	1	4	Inconsistencies	0	0.32	0.10	0.1	21
22	9	90	User needs	0	0.48	0.1	0.1	22
23	1	5	Impossibilities	0	0.26	0.1	0.1	23
24	4	43	Material non- availability	0	0.28	0.1	0.2	23
25	9	91	Review of the project by the proper governmental agency	0	0.17	0.09	0.1	25
26	2	18	Specified item became unavailable	0.06	0.06	0.06	0	26
27	3	31	Change in the owner's requirements	0.05	0.05	0.05	0	27
28	10	98	Mechanical and electrical provision	0.04	0.05	0.05	0.0	28

Chapter 6

Building Simulation Model

This chapter outlines the simulation model of change orders and their impact on cost, schedule, and productivity. The environment of the simulation was Arena-version 5.00.02 (cited in Al – helou, 2006).

6.1 Model Objectives

Two simulation models were built to simulate change orders' factors and their impact on building projects performance.

The first model was built to analyze the factors of change orders and their impact on building projects' performance.

The second model was built to help a project parties in predicting the impact of change orders on project performance.

6.2 Simulation by Arena

Al-helou (2006) cited that Arena has an object oriented environment to define system logic and physical components. The power afforded by Arena extends its ability to be integrated with other technologies, such as databases, drawing, modeling products, or spreadsheets. Moreover, it has such familiar interface that is compatible with Microsoft software packages.

Arena's product family consists of Arena Basic Edition, Arena Standard Edition, Arena Contact Center Edition, Arena Packaging Edition, Arena Professional Edition, and OptQuest for Arena which is used for the optimization process. The simulation model of change orders and their impact on building projects performance in Gaza Strip was built using Arena Basic Edition, version (5.00.02).

The "flowchart" is the general mechanism of simulation by Arena. The word "flowchart" has two main concepts behind; "flow" and "chart". Beginning with "chart", it is the main frame of the model that is built according to the logical aspects.

"Chart" consists of graphical objects called "modules", which are the objects of both chart and data, that define the process to be simulated. All information required to simulate a process is stored in the "modules". The second concept, "flow", represents the moving objects through a "chart". Such objects which are called "entities" are the items that are being served, produced, or otherwise acted on by a process. Arena software adopts the "production lines" strategy, which could be represented by static "workshops", and moving "products". The projection of such concept on the construction environment makes the entire project represented as objects "entities", that pass through the chart's modules to be performed, cited in Al – helou (2006).

6.3 Input and Output Data

The input of the simulation model of change orders and their impact was the number of change orders occurred by factors in the actual project, while the output were

1- Impact on cost and time for each factor
2- Total impact on cost, time, and productivity on the project (Figure 6.1).

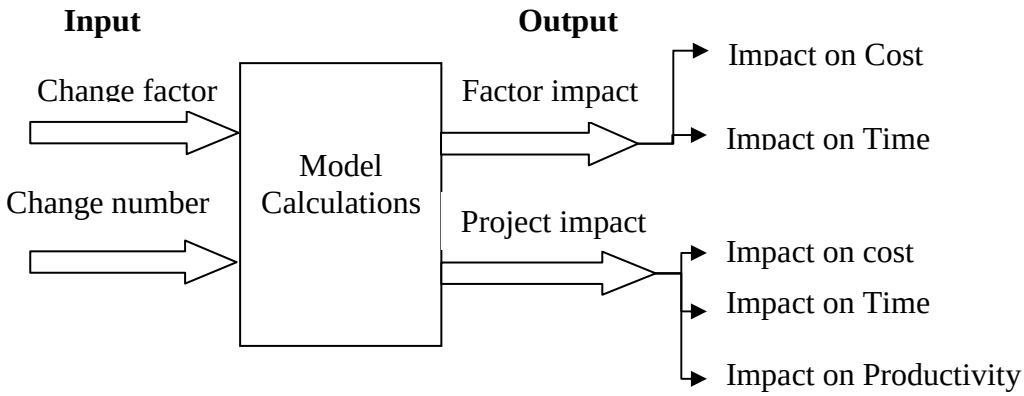


Figure 6.1: Model input and output

6.4 Model Flow Chart

Flow chart in Figures 6.2a and 6.2b was the first basic step in building the simulation model of the change orders and their impact on performance as follows:

1- As shown in Figure 6.2a, the flow chart starts with generating 171 entities to use them in the sub-models as seen latter.
2- 10 entities enter the change orders' group factors sub-model and the rest goes to the productivity loss sub-model.
3- Once the entity enters the sub-model of change orders' group factors (Figure

6.2b), it directly separates into a number of batches equal in number to the number of factors in the sub-model and each batch contains 100 entities.

4- The batch which enters into the factor is stopped to allow only an equal number of entities to the number of change orders to enter.
5- After that the batch is separated into three batches.
6- The first batch is separated into a number equals to [100 x (entities in the batch)] and they are used to calculate the impact of the factor on time by choosing the impact from the time impact probability distribution (Table 6.4), then the value is sent to time block, see Figure 6.2a.
7- The time block collects all impacts on time coming from each factor. Then the result is directed to "output time impact" block.
8- The second batch is separated into a number equals to [100 x (entities in the batch)] and they are used to calculate the impact of the factor on percentage of change on project in terms of original budgeted work hours by choosing the impact from the percentage of change on project in terms of original budgeted work hours impact probability distribution (Table 6.5), then the value is sent to PC block, see Figure 6.2a.
9- The PC block collects all impacts on PC coming from each factor. Then the result is then directed to "sum coming PC" block, see Figure 6.2a.
10- The third batch is separated into a number equals to [100 x (entities in the batch)] and they are used to calculate the impact of the factor on cost by choosing the impact from the cost impact probability distribution, see Table 6.3.
11- Impact on cost is checked if its positive or negative, the positive impact goes to "+cost" block while the negative impact goes to "- cost" block, see Figure 6.2a.
12- The "+ cost" block collects all positive impact on cost coming from each factor. Then the value is directed to "output cost impact" block.
13- The "- cost" block collects all negative impact on cost coming from each factor. The value is then directed to "output cost impact" block.
14- The remaining entities are used to calculate other factors of productivity loss as shown in Figure 6.2a as follows:
    a- 37 entities are used to form the constant shown in Equation 2.5. After that they go to "sum all productivity factors" block as a positive number.

b- 8 entities go to "Calculate 0.08 PM" block, then the value is calculated from probability distribution. After that the value goes to "sum all productivity factors" block as a negative number.

c- 100 entities (represent 100%) go to "Calculate 0.17 %Owner CO" block, then the value is calculated from probability distribution and goes to "sum all productivity factors" block as a negative number.

d- 9 entities go to " Calculate 0.09 Productivity" block, then they go to "sum all productivity factors" block as a negative number.

e- 5 entities go to " Calculate 0.05 Overmanning" block, then they go to "sum all productivity factors" block as a negative number.

f- 2 entities go to " Calculate 0.02PT" block, then they go to "sum all productivity factors" block as a positive number.

g- 12% of the entities which reach to the "sum coming PC" block go to "sum all productivity factors" block as a positive number.

h- "Sum all productivity factors" block adds all coming values together, then it sends the result to " output productivity loss" block as seen in Figure 6.2.

15- At the end, the "Impact on Performance" block previews the impact of change orders on cost, time, and productivity:

a- The "Output Time" block previews the impact on time.

b- The "Output Cost" block previews the impact on cost.

c- The "Output productivity loss" block previews the impact on labor productivity.

6.5 Arena Modules

The simulation model was built by using the modules that are located at the "basic process panel". Modules such graphical objects that define the process, and containing all of the required information. Modules have two main types; "flowchart" modules and "data" modules. The "basic process panel" consists of eight flowchart modules and six data modules (Figure 6.3). In the side panel, each of the "flowchart" modules has a specific figure such as: rectangular, diagonal, etc., while "data" modules were acted with small tables. To build a flowchart in the Arena's environment, the required "flowchart" module has to be dragged and dropped via mouse cursor into the chart's area. All of the dropped modules must be connected

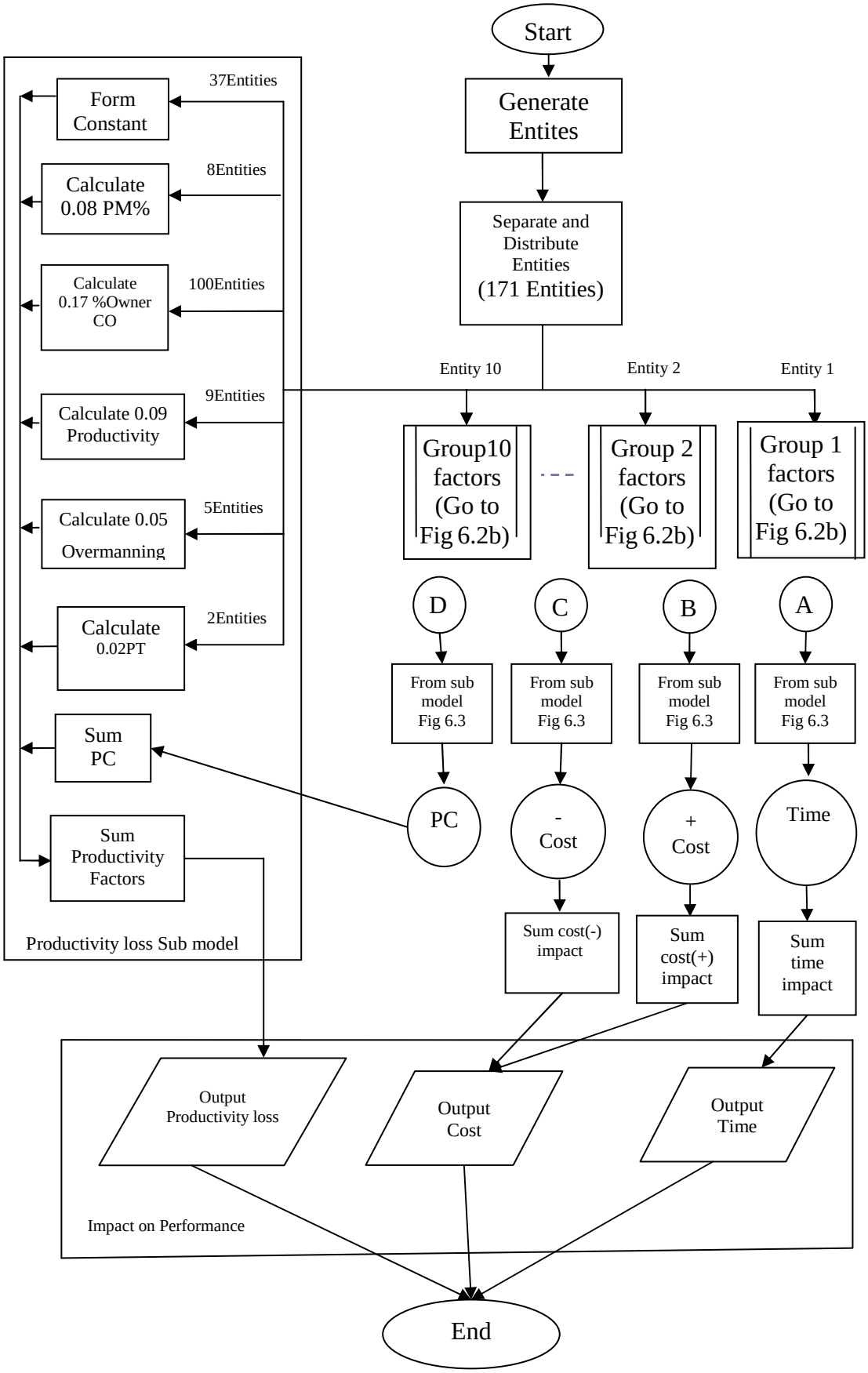


Figure 6.2a: Flow chart of change orders and impact model

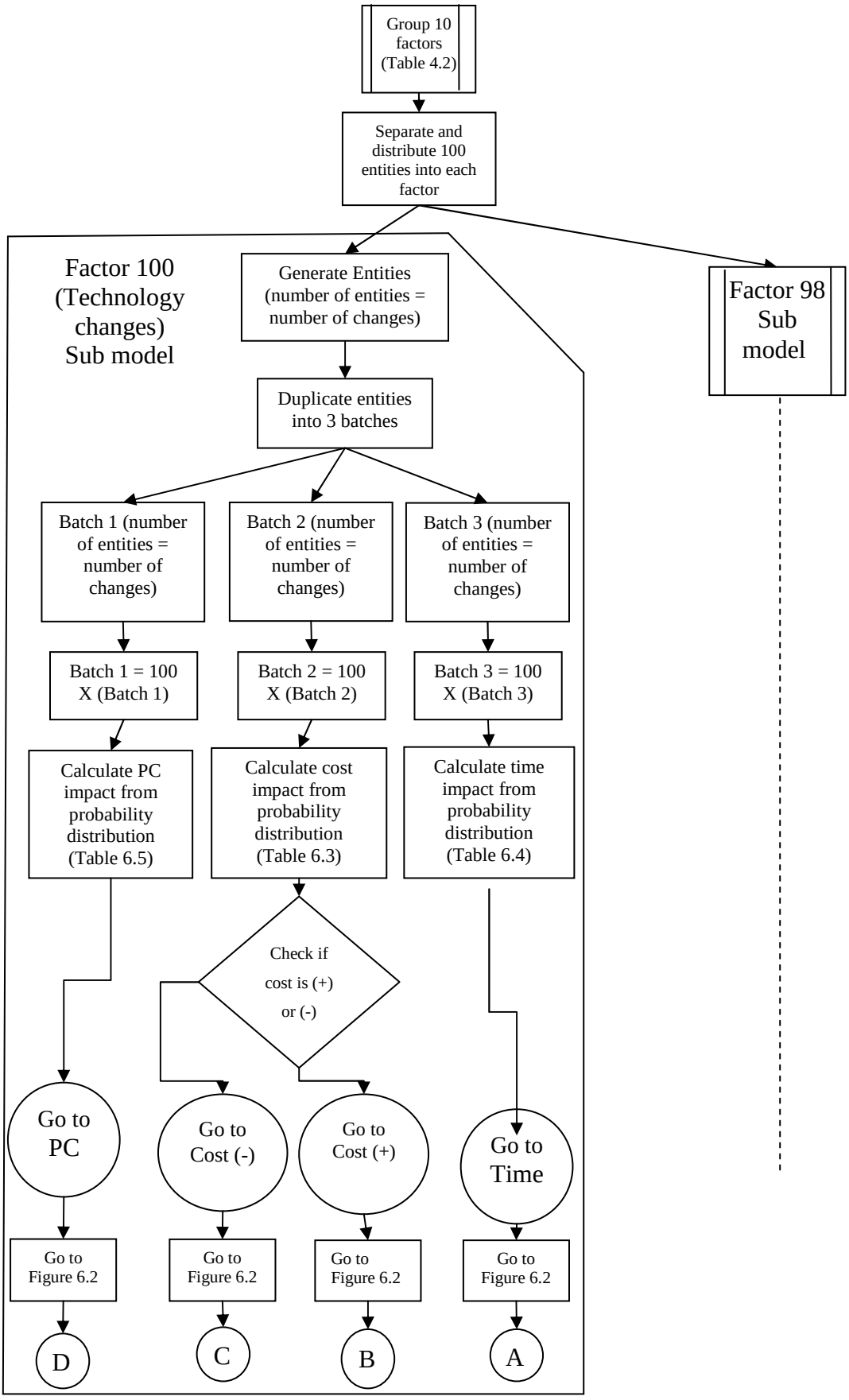


Figure 6.2b: Flow chart of change orders and impact model

from their both ends with one connection at least, except the Create and Dispose modules. Table 6.1 clarifies the flowchart modules.

A Data module is simply a table that can be fed with different data features. The Data module's table could be opened by double clicking its icon at the "basic process panel" (cited in Al – helou, 2006).

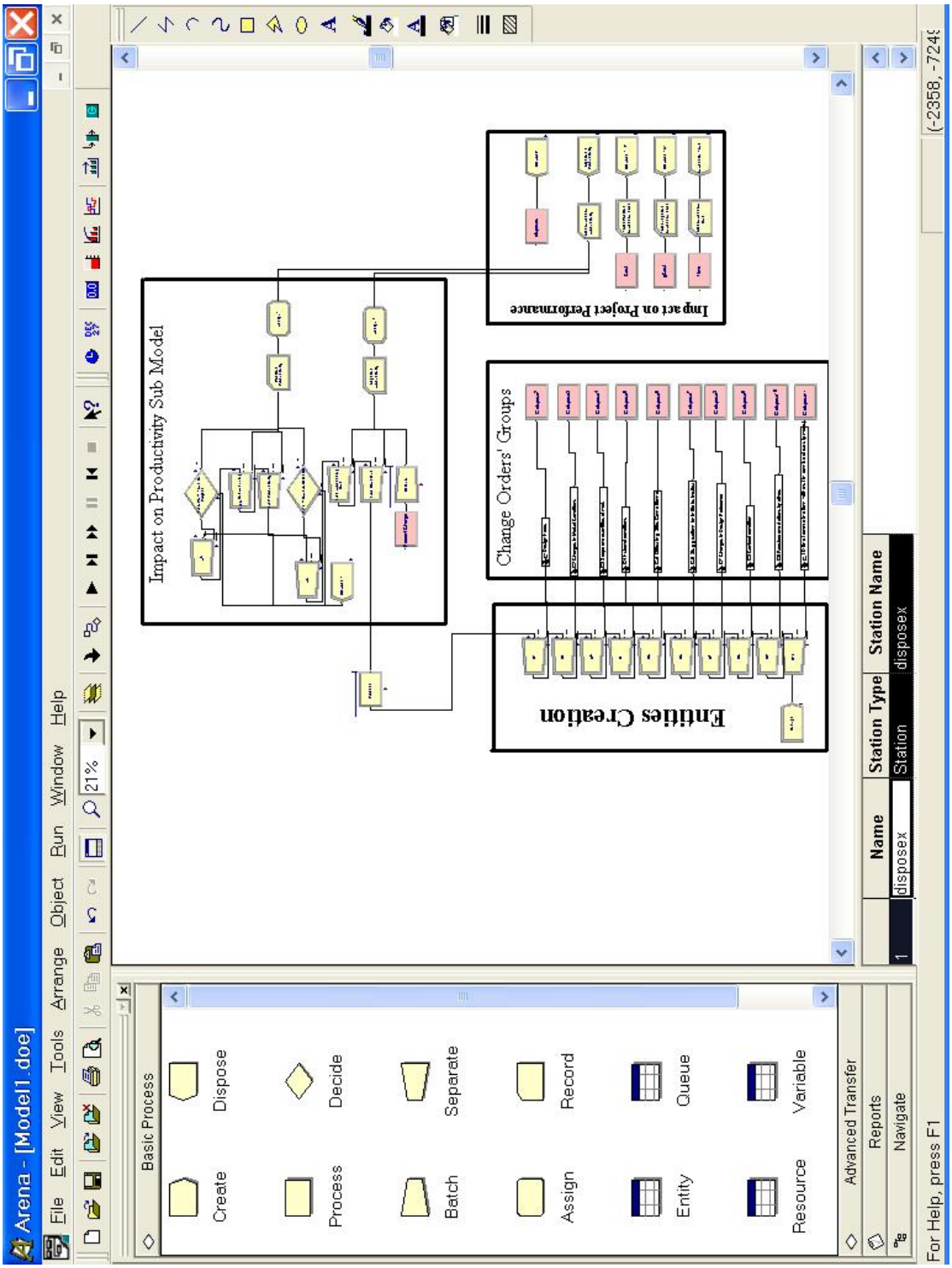
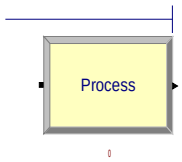
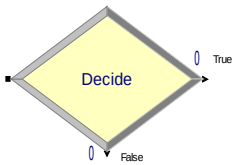
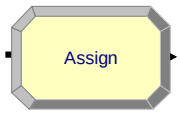
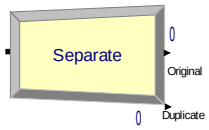
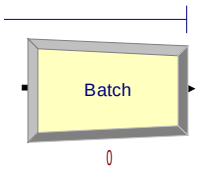
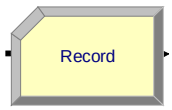


Figure 6.3: Arena software window

Table 6.1: Arena flowchart modules (cited in Al – Helou, 2006).

Module	Figure	Brief Description
Create		The starting point for entities in a model.
Process		The main processing method in the simulation process including resources delay type identification, and assignments dialogues.
Decide		This module allows for decision making process in the system.
Assign		It is used for assigning new values to any of system variables during the simulation process
Separate		This module can be used to either copy an incoming entity into multiple entities or to split a previously batched entity.
Batch		Intended as the grouping mechanism for the simulation model's entities.
Record		Collects statistics in the simulation model.
Dispose		The ending point for entities in a model (The termination of the simulation process).

6.6 Data Preparation

Before laying out the simulation model, four questions have to be asked. The questions are:

1- how can we produce the change orders per each factor in the model?

2- what is the impact on cost probability distributions per each factor?

3- what is the impact on time probability distributions per each factor?

4- what is the impact on percentage of change on project in terms of original

budgeted work hours probability distributions per each factor?

6.6.1 Change orders generation

To answer the first question, entities in the queuing line of the factor have to be passed with equal number to the number of change orders occurring in actual project due to the respective factor (Table 4.21). So, the Process module with (seize, delay, release) action is activated, that means, a resource with certain service time serves a number of entities in queuing line to produce the occurring number of change orders. The question then is supposed to be "What is the time that the resource needs to produce the number of change orders?" The answer is summarized in the following:

1- The project life time is simulated by one day in the model.
2- The resource must serve the entities in the queuing line to produce a number of entities equal to the number of change orders.
3- To produce only one entity, the service time has to be one day. But to produce two entities, the service time has to be 0.5 day which means that the resource releases 1 entity per 0.5 day.
4- To produce any occurrence, then the service time has to be $\frac{1}{\text{Occurrences}}$ day.
5- But to make sure that the last entity in service goes out, the time of service has to be less than the time in the previous point.
6- To make sure the entities are not more than the number of change orders produced, the time of service has to be less than the time needed to produce the occurrences +1, so the service time has to be less than $\frac{1}{\text{Occurrences} + 1}$ day.
7- Therefore, the general average needed service time is given in Equation 6.1.

$$\frac{1}{2} \times \left(\frac{1}{\text{Occurrences}} + \frac{1}{\text{Occurrences} + 1} \right) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots eq\ 6.1$$

Table 6.2 shows the occurrences of change orders and the service time needed for each factor. The time of service was calculated according to Equation 6.1.

Table 6.2: The number of change orders and their service times

#F	Factor	Occurrences	Service time (day) Eq. 6.1
1	Design errors	14	0.069
2	Omissions	1	0.750
4	Inconsistencies	7	0.134
5	Impossibilities	3	0.292
6	Change in design request	1	0.750
6	Change in design request	1	0.750
8	Inadequate design	70	0.014
15	Noncompliance of design with owner's requirements	5	0.183
18	Specified item became unavailable	1	0.750
21	Significant changes in the quantities of work	39	0.025
21	Significant changes in the quantities of work	6	0.155
27	Plan errors	3	0.292
29	Change of plans or scope by owner	2	0.417
31	Change in the owner's requirements	2	0.417
32	Owner desire to improve his financial conditions	23	0.043
39	Uncovering disclosed existing conditions	3	0.292
41	Strikes	1	0.750
42	Extreme whether condition	2	0.417
43	Material non- availability	3	0.292
44	Israeli closure	9	0.106
47	Differing site conditions	6	0.155
48	Safety considerations	24	0.041
49	Differing subsurface conditions	11	0.087
52	Suggestions to Initiate more economical construction	4	0.225
53	Suggestions to Initiate more Quality	44	0.022
54	Value engineering (+ cost)	1	0.750
54	Value engineering (- cost)	3	0.292
56	Delays in the Project	2	0.417

Table 6.2: The number of change orders and their service times (contd.)

#F	Factor	Occurrences	Service time (day) Eq. 6.1
69	Consultant's lack of judgment and experience	1	0.750
71	Honest wrong beliefs of consultant	2	0.417
80	Contractor's lack of judgment and experience	1	0.750
83	Utility companies	1	0.750
85	Local governments	1	0.750
87	A prevalent practice on this project and/or district	6	0.155
90	User needs	30	0.033
91	Review of the project by the proper governmental agency	2	0.417
95	Change in economic conditions	7	0.134
96	Socio-cultural factors	6	0.155
98	Mechanical and electrical provision	2	0.417
100	Technology changes	5	0.183

6.6.2 Impact of change orders on cost

To answer the second question, "% Cost impact per each occurrence", Table 4.9 was inserted to the Input Analyzer program of Arena to fit the optimum probability distribution for each factor. Every change occurred due to any factor is separated into 100 entities where every entity represents 1%. The cost probability distribution was entered into a Decide module to let a ratio from the entities passes according to the probability distribution (Figure 6.14). The ratio equals the actual impact. The fitted probability distributions for change orders factors are shown in Table 6.3.

Table 6.3: Impact of change orders on cost

#F	Factor	Expression of impact on cost (%)	Square Error
1	Design errors	GAMM(0.143, 0.943)	0.016
2	Omissions	0.16	
4	Inconsistencies	EXPO(0.0814)	0.032

Table 6.3: Impact of change orders on cost (contd.)

#F	Factor	Expression of impact on cost (%)	Square Error
5	Impossibilities	1.5 * BETA(0.435, 0.695)	0.092
6	Change in design request	2.89	-
6	Change in design request	3.43	-
8	Inadequate design	LOGN(0.267, 0.446)	0.002
15	Noncompliance of design with owner's requirements	5 * BETA(0.476, 0.505)	0.091
18	Specified item became unavailable	0.63	-
21	Significant changes in the quantities of work	2.48 * BETA(0.751, 3.65)	0.003
21	Significant changes in the quantities of work	LOGN(0.393, 0.651)	0.040
27	Plan errors	WEIB(0.596, 0.48)	0.114
29	Change of plans or scope by owner	3 + 9 * BETA(0.484, 0.466)	0.082
31	Change in the owner's requirements	0.14	0.000
32	Owner desire to improve his financial conditions	WEIB(0.635, 0.732)	0.015
39	Uncovering disclosed existing conditions	0.22 + 1.08 * BETA(0.0499, 0.0783)	0.068
41	Strikes	1.38	0.000
42	Extreme whether condition	0	0.000
43	Material non- availability	1.24 * BETA(0.584, 0.75)	0.089
44	Israeli closure	0	0.000
47	Differing site conditions	GAMM(6.31, 0.644)	0.026
48	Safety considerations	WEIB(0.342, 0.668)	0.003
49	Differing subsurface conditions	LOGN(1.41, 1.23)	0.026
52	Suggestions to Initiate more economical construction	UNIF(0.01, 0.89)	0.050
53	Suggestions to Initiate more Quality	WEIB(0.659, 0.698)	0.003
54	Value engineering	4.82	0.000

Table 6.3: Impact of change orders on cost

#F	Factor	Expression of impact on cost (%)	Square Error
54	Value engineering	ERLA(0.131, 25)	0.201
56	Delays in the Project	EXPO(1.36)	0.297
69	Consultant's lack of judgment and experience	0	0.000
71	Honest wrong beliefs of consultant	3.42 * BETA(0.479, 0.537)	0.100
80	Contractor's lack of judgment and experience	0.09	-
83	Utility companies	0.2	-
85	Local governments	0	-
87	A prevalent practice on this project and/or district	10 * BETA(0.0447, 0.171)	0.031
90	User needs	LOGN(0.17, 0.32)	0.005
91	Review of the project by the proper governmental agency	WEIB(0.0117, 0.563)	0.242
95	Change in economic conditions	LOGN(1.56, 2.65)	0.022
96	Socio-cultural factors	EXPO(0.133)	0.031
98	Mechanical and electrical provision	BETA(0.602, 0.726473)	0.179
100	Technology changes	TRIA(0.08, 0.17, 0.18)	0.067

6.6.3 Impact of change orders on time

To answer the third question, "% Time impact per each occurrence", Table 4.9 was inserted to the Input Analyzer program of Arena to fit the optimum probability distribution for each factor. Every change occurred due to any factor is separated into 100 entities where every entity represents 1%. The time probability distribution was entered into a Decide module to let a ratio from the entities passes according to the probability distribution. The ratio equals the actual impact. The fitted probability distributions for change orders factor are shown in Table 6.4.

Table 6.4: Impact of change orders on time

#F	Factor	Expression of impact on time (%)	Square Error
27	Plan errors	EXPO(1.54)	0.118
29	Change of plans or scope by owner	EXPO(0.465)	0.297
42	Extreme whether condition	1.33	0.000
43	Material non- availability	WEIB(1.6, 0.851)	0.166
44	Israeli closure	TRIA(2, 4.3, 25)	0.128
47	Differing site conditions	GAMM(7.88, 0.635)	0.375
48	Safety considerations	ERLA(0.174, 1)	0.003
49	Differing subsurface conditions	3 * BETA(0.0307, 0.198)	0.019
54	Value engineering	0.37	0
69	Consultant's lack of judgment and experience	1.48	0
91	Review of the project by the proper governmental agency	5 * BETA(0.476, 0.505)	0.091

6.6.4 Impact of change orders on PC

To answer the fourth question, "% PC impact per each occurrence", Table 4.9 was inserted to the Input Analyzer program of Arena to fit the optimum probability distribution for each factor. Every change occurred due to any factor is separated into 100 entities where every entity represents 1%. The PC probability distribution was entered into a Decide module to let a ratio from the entities passes according to the probability distribution. The ratio equals the actual impact. The fitted probability distributions for change orders factors are shown in Table 6.5.

Table 6.5: Impact of change orders on the percentage of change

#F	Factor	Expression of impact on PC (%)	Square Error
1	Design errors	LOGN(0.101, 0.233)	0.007
4	Inconsistencies	EXPO(0.101)	0.024
5	Impossibilities	ERLA(0.0933, 1)	0.213
6	Change in design request	0.24	0.000
8	Inadequate design	EXPO(0.278)	0.002

Table 6.5: Impact of change orders on the percentage of change (contd.)

#F	Factor	Expression of impact on PC (%)	Square Error
15	Noncompliance of design with owner's requirements	GAMM(2.02, 0.547)	0.043
18	Specified item became unavailable	0.06	-
21	Significant changes in the quantities of work	WEIB(0.254, 0.525)	0.001
27	Plan errors	3.69 * BETA(0.414, 0.672)	0.082
29	Change of plans or scope by owner	3 + 15 * BETA(0.354, 0.415)	0.054
31	Change in the owner's requirements	0.05	-
32	Owner desire to improve his financial conditions	ERLA(0.463, 1)	0.008
39	Uncovering disclosed existing conditions	NORM(0.26, 0.03)	0.000
41	Strikes	2.1	-
43	Material non- availability	ERLA(0.0933, 1)	0.206
47	Differing site conditions	LOGN(0.879, 1.52)	0.034
48	Safety considerations	WEIB(0.202, 0.596)	0.002
49	Differing subsurface conditions	LOGN(0.837, 1.83)	0.027
53	Suggestions to Initiate more Quality	WEIB(0.291, 0.573)	0.008
54	Value engineering	7.14	-
71	Honest wrong beliefs of consultant	LOGN(1.39, 7.47)	0.250
87	A prevalent practice on this project and/or district	EXPO(0.57)	0.045
90	User needs	LOGN(0.13, 0.29)	0.006
91	Review of the project by the proper governmental agency	ERLA(0.085, 1)	0.297
95	Change in economic conditions	12 * BETA(0.363, 1.04)	0.050
96	Socio-cultural factors	WEIB(0.0886, 0.71)	0.051
98	Mechanical and electrical provision	TRIA(0.03, 0.039, 0.06)	0.232
100	Technology changes	LOGN(0.165, 0.176)	0.063

6.7 Model Layout

The developed model consists of 4 main parts as the following:

1- Entities generation part consists of a Create module, 10 Separate modules, and a process module, see Figure 6.4.

2- 10 sub-models of change orders' groups part. These sub-models are: design errors, change in market conditions, scope and quantities of work, external conditions, different site conditions, suggestion to initiate better, changes in design performance, contract conditions, actions by others, and final coordination, see Figure 6.8.

3- Productivity loss sub-model part which is modeled according to Equation 2.5, see Figure 6.15.

4- Impact of change orders on project performance part, see Figure 6.18.

The model consists of 690 modules from 12 kinds of flow chart modules. Table 6.6 shows the details of the 690 modules.

Table 6.6: Flow chart modules for each main sub-model

Sub-model	Create	Process	Assign	Decide	Separate	Batch	Record	Dispose	Route	Station	Total
Entities generation part	1	1	-	-	10	-	-	-	-	-	12
10 sub-models of change orders' groups part	-	40	-	120	160	-	160	-	170	-	650
Productivity loss sub-model part	-	-	2	2	6	1	2	1	-	1	15
Impact of change orders on project performance part	-	-	-	-	-	-	4	5	-	4	13
Total	1	41	2	122	176	1	166	6	170	5	690

6.7.1 Entities generation

The simulation model of change orders and their impacts (Figure 6.4) starts with generating and distributing entities as shown in Figure 6.5 according to the following systematic steps:

1- The simulation model starts with generating one entity. A Create module with a name "change" is used to generate the entity. The time per arrival in the

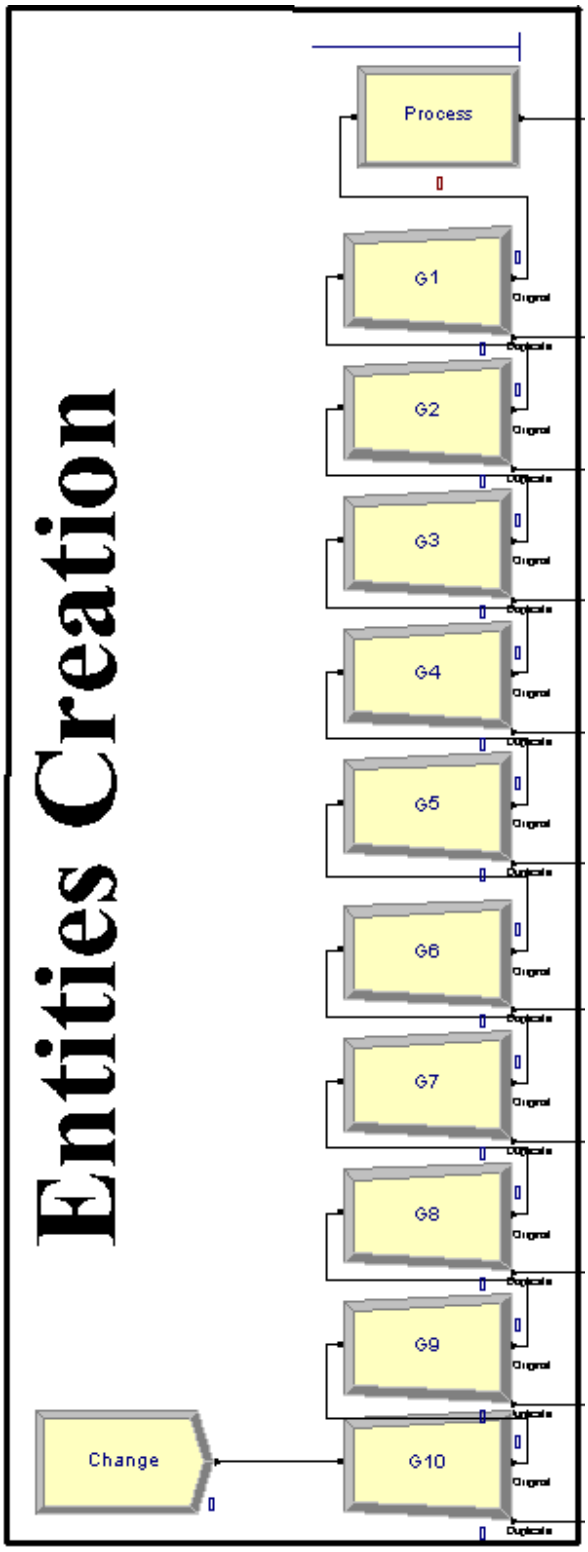


Figure 6.4: Entities generation part

module is constant with value equals to 5 seconds where we need a negligible time compared with the project life, so the entity shall be generated in the first 5 second of the model life time (Figure 6.5). The entity per arrival is one with

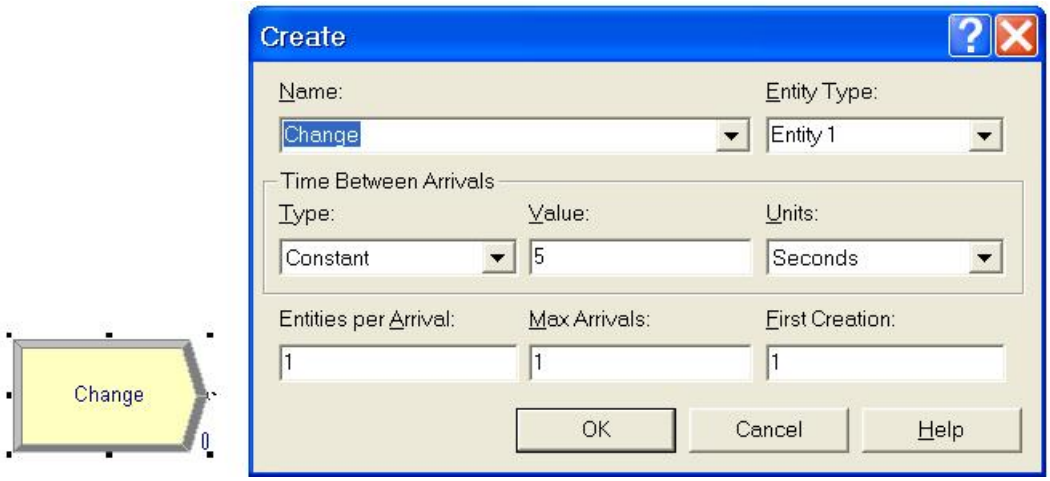


Figure 6.5: Create module data entry window

maximum arrival equals one. The previous module means that only one entity will be generated in a time equivalent to the start time of the model.

2- After generating the entity, it enters into a Separate module called "G10". G10 module separates the entity into two (Figure 6.6), one goes to sub-model called " G10 final coordination without in contract equipment" in change orders groups part and the second entity goes to other Separate module called "G9". The same action is repeated in a series of Separate modules till reaching to G1 module. G1 module sends one entity to "G1 design errors" sub-model and send the second to a "process" module before reached to productivity loss sub-model.

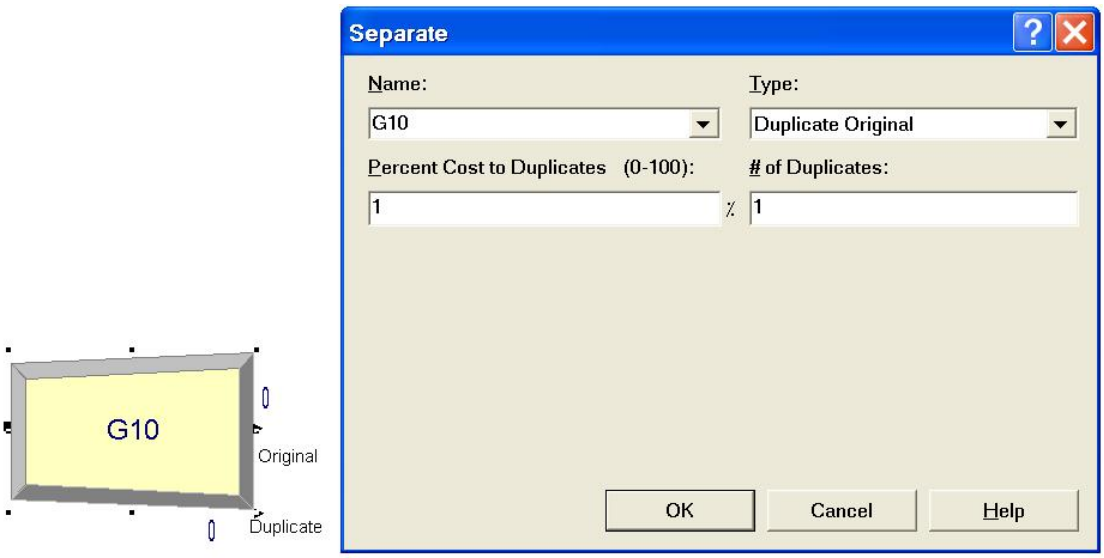


Figure 6.6: Separate module data entry window

3- There is no delay actions in productivity loss sub-model, so Process module (Figure 6.7) delays the entity (1 hour) to guarantee that it will not dispose before starting the simulation model see Figure 6.5 .

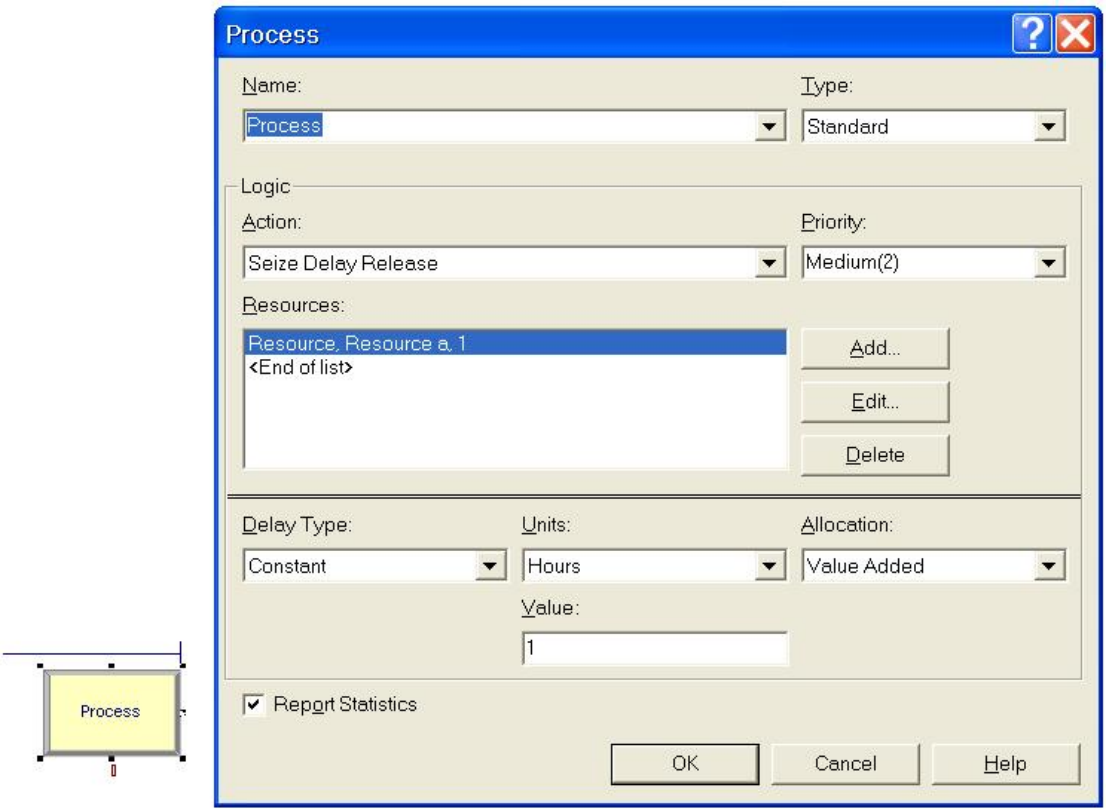


Figure 6.7: Process module data entry window

6.7.2 Change orders' groups part

This part consists of 10 sub-models (Figure 6.8). As seen in section 6.7.1 a series of Separates modules feed each sub-model with one entity. To be aware of what happens in change orders groups sub-models, "G10 final coordination without in contract equipment" sub-model was taken as an example as follows:

1- "G10 final coordination without in contract equipment" sub-model consists of two factors sub-models , the first one is "Factor 98 - Mechanical and electrical provision" sub-model and the second is "Factor 100 - Technology changes" sub-model. Factor 100 is taken here as an example see Figure 6.9 and Table 4.1.

2- Once the entity enters "G10 final coordination without in contract equipment", a series of Separate modules send 100 entities (represent 100%) to each factor

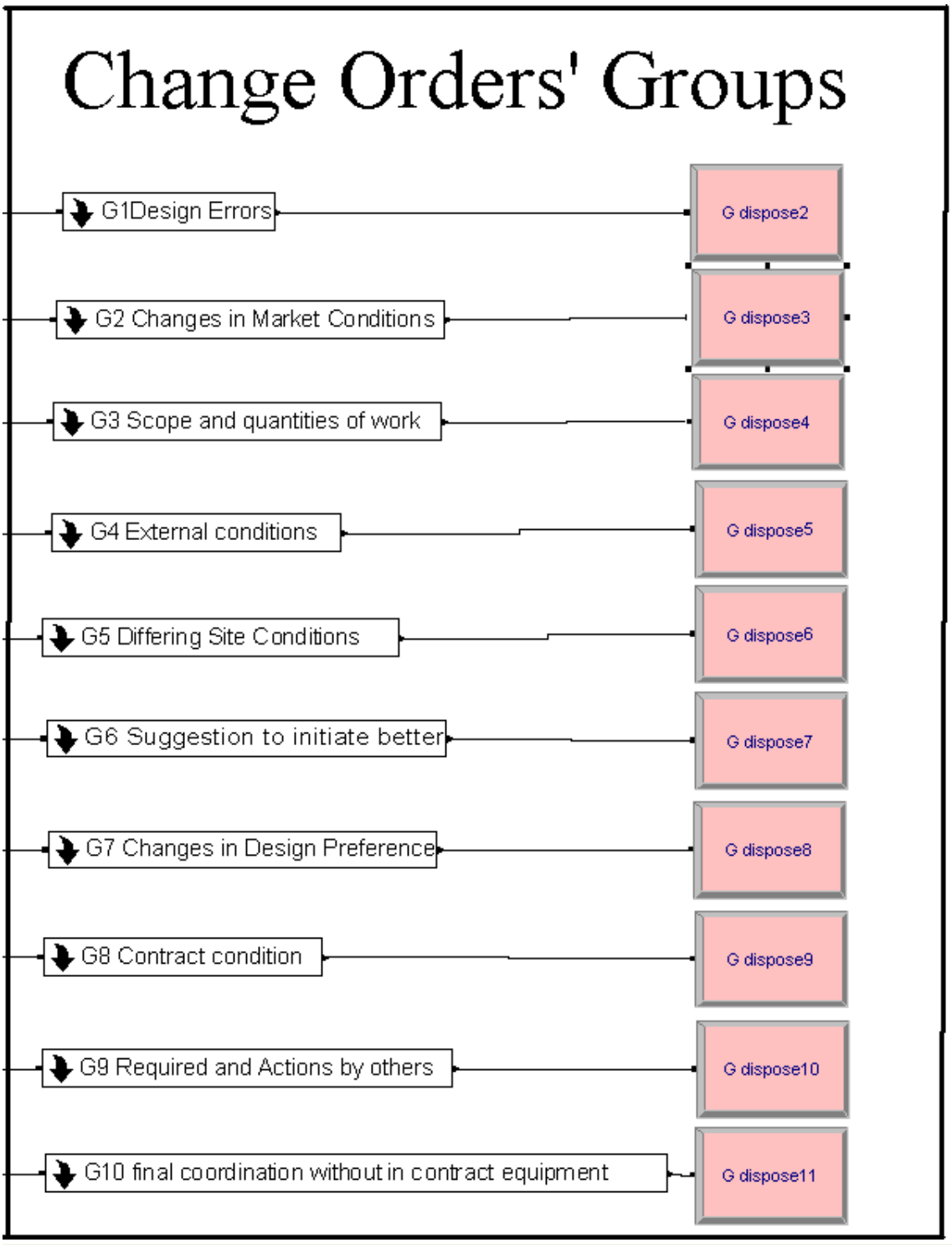


Figure 6.8: Change orders' groups sub-models

in the group. These 100 entities enter into a queuing line of a Process module. The resource in the Process module serves the entities in the queuing line to produce an equal number of entities to the number of change orders in the actual project due to this factor.

3- When The entity which is produced from entities generation part

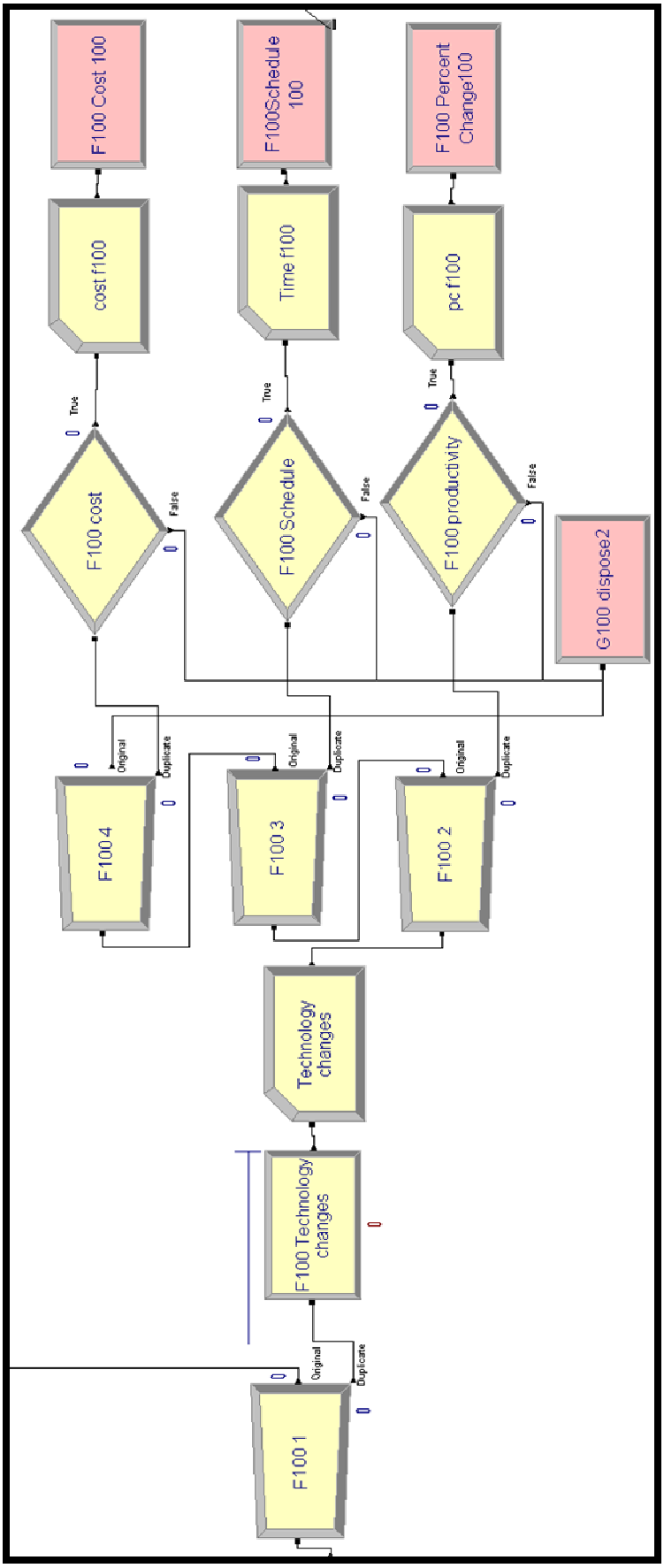


Figure 6.9: Representative Factor sub model (G10 sub-model)

(Section 6.7.1), enters Group 10 sub-model, it goes to Separate module (Figure 6.10) to separate it into an entity and a batch of 100 entities. The batch goes to "F100" queuing line and the entity goes to another Separate module with the same function to feed "F98".

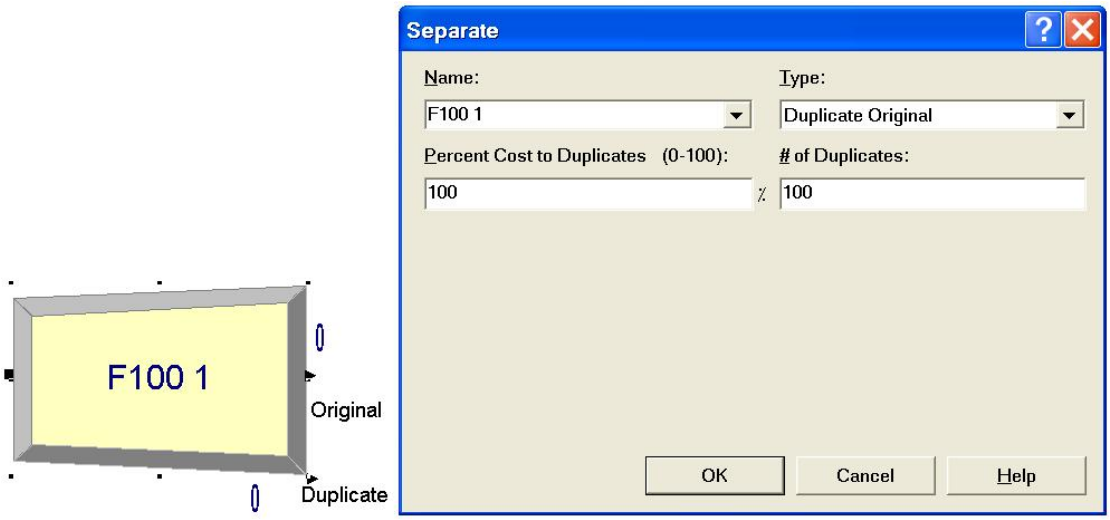


Figure 6.10: Separate module which is used to feed factors by entities

4- "F100 Technology changes" Process module (Figure 6.11) serves 100 entities in the queuing line to let only for an equal number of entities equal to the actual change orders enters. So, a resource with action "Seize Delay Release" serves entities in the queuing line with [delay type: constant, Unit: day, and Value: 0.183 (Table 6.2)].
5- Entities which pass "F100 Technology changes" Process module go to a Record module (Figure 6.12) with (Type: count and value = 1). The Record module stores the value in a counter with name (a number of change) and all other factors store their values with the same name so the total number of change orders of the project appears in the final results sheet.
6- After that the entities which pass the Recored module enter into a series of Separate modules to produce three batches. each batch equal to [(entities pass the Record module) x 100] (Figure 6.10).
7- The first batch enters "F100 cost" Decide module (Figure 6.13). The module produces change orders impact on cost due to this factor. The impact on cost due to this factor is given by probability distributuion in Table 6.3.
8- After (the number of entities which equals to the value of impact on cost)

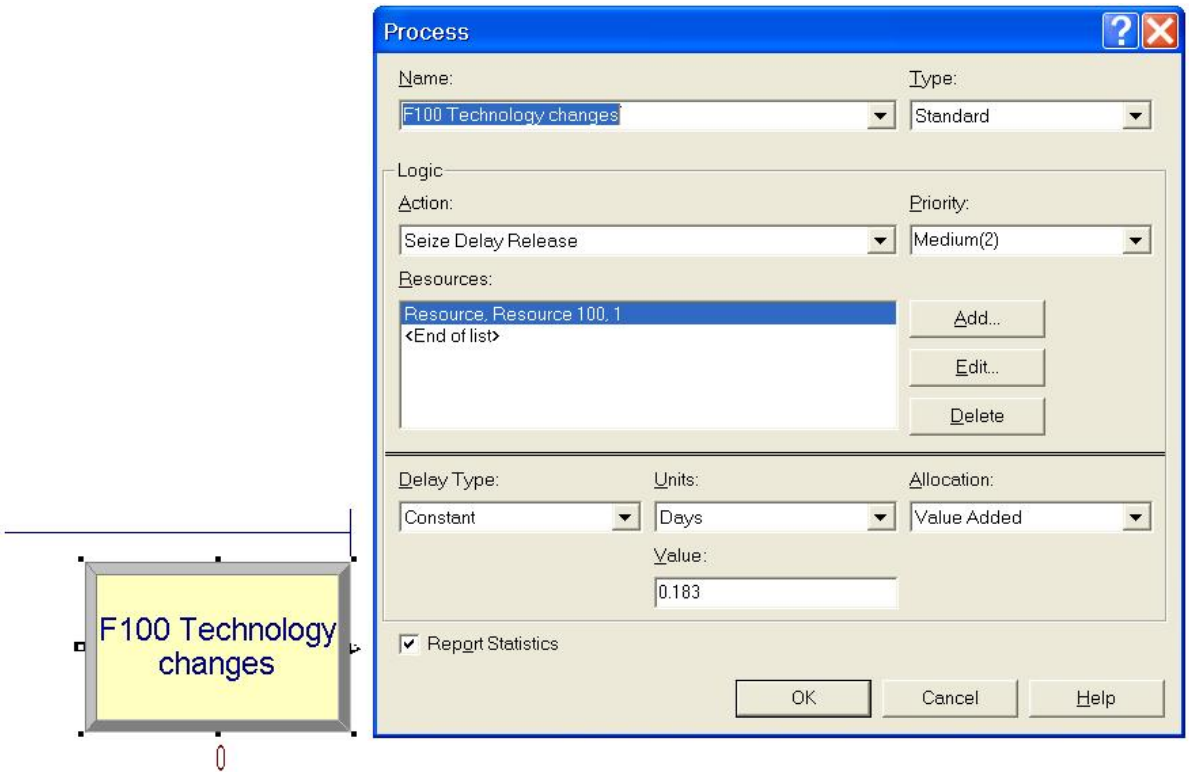


Figure 6.11: Module which used to produce change orders

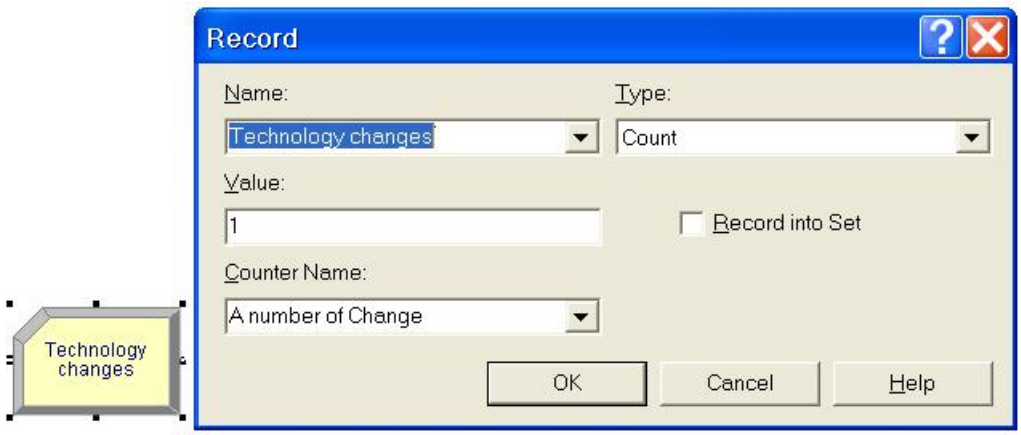


Figure 6.12: Record module

leaves the Decide module, it enters into a Record modul to count it, then it goes to a Route module.

9- The Route module (Figure 6.14) sends entities to a Station called cost in "impact of changes on project performance" part.

10- The second batch enters "F100 schedule" Decide module (Figure 6.9). This module produces the impact of change orders on time. The impact on time is given by the probability distributuion seen in Table 6.4. After (the number of

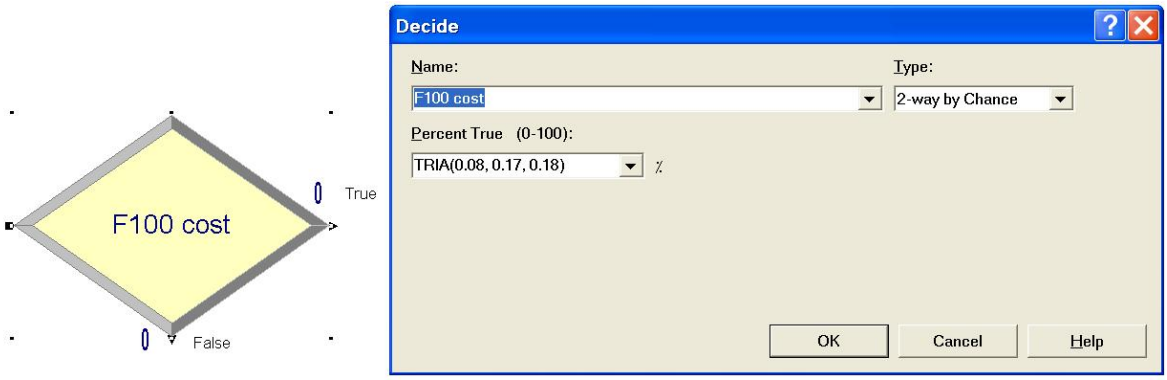


Figure 6.13: Decide module

entities which equals to the value of impact on time) leaves the Decide module, they enter a Record module to count them, then they go to a Route module. The Route module sends entities to a Station module called "Time" in impact on performance part.

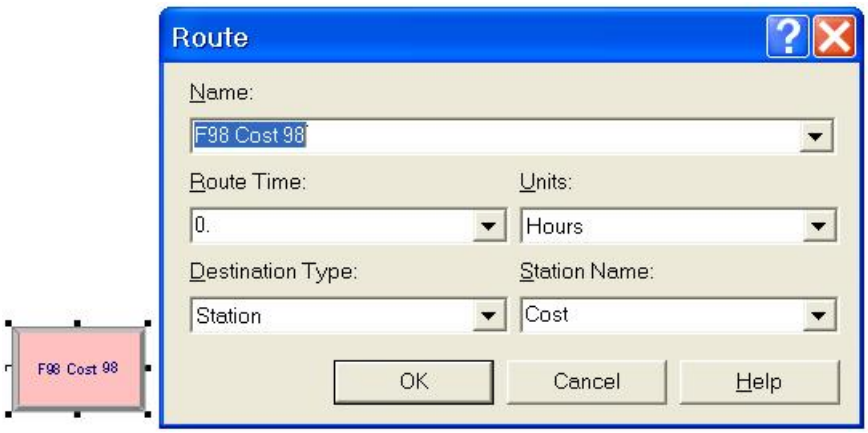


Figure 6.14: Route module

11- The third batch enters "F100 productivity" Decide module (Figure 6.9). This module produces the impact of change orders on percentage of change on project in terms of original budgeted work hours. The impact on "Percentage of change on project in terms of original budgeted work hours" is given by the probability distributuion seen in Table 6.5. After the number of entities which equal to the value of impact on percentage of change on project in terms of original budgeted work hours leave the Decide module, they enter a Record module to count them, then they go to a Route module. The Route module sends entities to a Station module called "Percent Change" in impact on

productivity sub-model.

6.7.3 Productivity loss sub-model

This part consists of 15 modules (Figure 6.15). As seen in section 6.7.1 the last Separate module in the entities generation part feeds a Process module with one entity. The Process module delays the entity to guarantee that the entity will not be disposed before starting the simulation model.

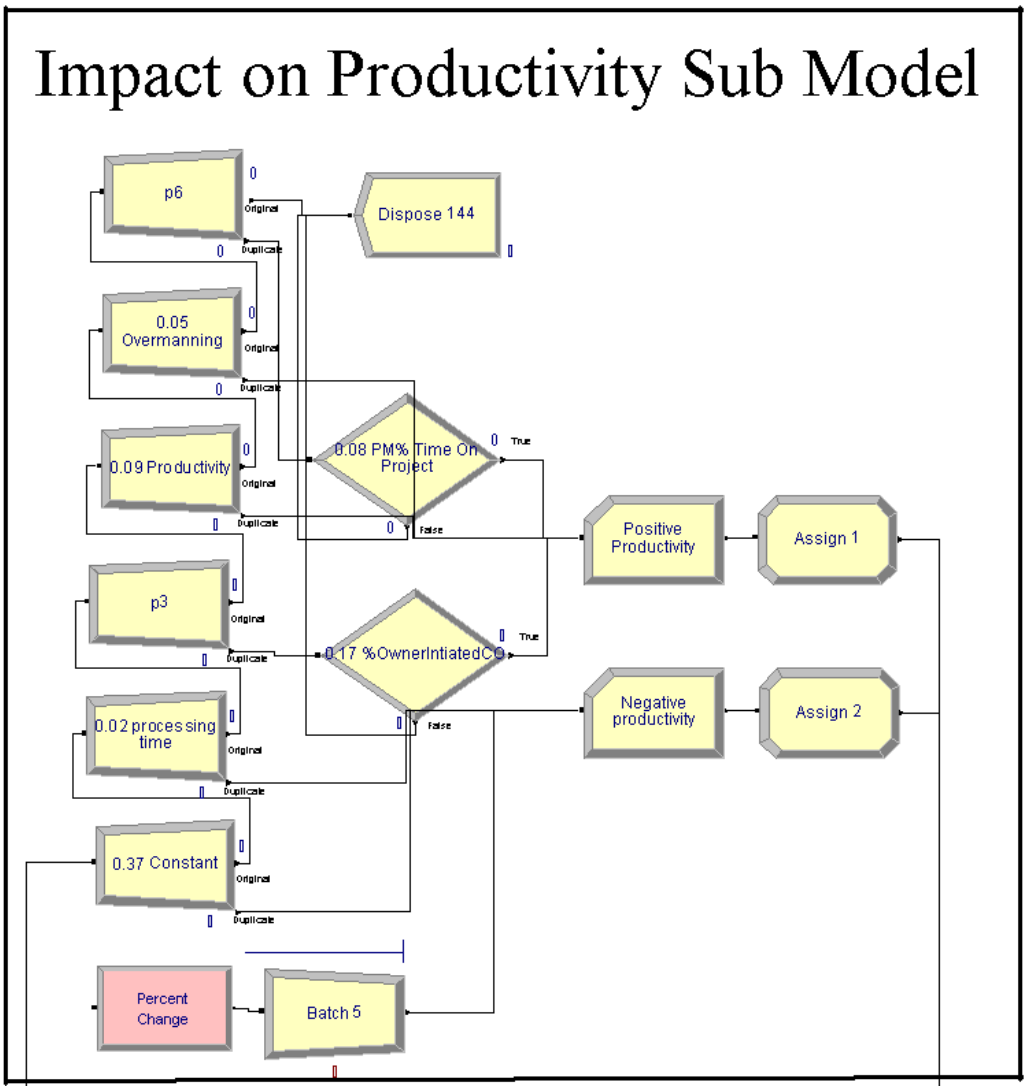


Figure 6.15: Impact on productivity sub-model

The impact on productivity sub-model starts once the entity comes from the entities generation part according to the following systematic steps.

1- Productivity loss is simulated according to the following equation (CII, 2000):

$$\%Delta = 0.37 + 0.12\ Percent\ Change - 0.08\ PM\ \%\ Time\ On\ Project - 0.17\ \%\ OwnerInitiatedCO - 0.09\ Productivity - 0.05\ Overmanning + 0.02\ Processing\ Time$$

2- When the entity reaches to productivity loss sub-model, it goes to a Separate module to produce another entity and a batch of 37 entities. The entity goes to (0.02 processing time) Separate module and the batch goes to "negative productivity" Record module forming the constant in the previous equation.

3- The entity which reaches to "0.02 processing time" separates into an entity and a batch of 2. The entity goes to a Separate module with name (P3) and the batch goes to "negative productivity" Record module.

4- The entity which reaches to "P3" module separates into two entities. One of them goes to "0.17 %Owner Intiated CO" Decide module and the another goes to Separate module with name "0.09 Productivity".

5- "%OwnerIntiatedCO" Decide module generates percentage of change orders initiated by the owner and sends it to positive productivity Record module.

6- "0.09 Productivity" Separate module separates the entity into an entity and a batch of 9 entities. The entity goes to "0.05 Overmanning" Separate module and the batch goes to "positive productivity" Record module.

7- "0.05 Overmanning" Separate module separates the entity into an entity and a batch of 5. The entity goes to "P6" Separate module and the batch goes to positive productivity Record module.

8- "P6" Separate module separates the entity into an entity and a batch of 8. The entity goes to Dispose module and the batch goes to "0.08 PM% Time On Project" Decide module.

9- "0.08 PM% Time On Project" Decide module calculates the value of percentage of time the project manager spends on the project and sends it to "Positive productivity" Record module.

10- Percentage of change on project in terms of original budgeted work hours which is collected from 37 change orders factors in the "Change Orders' Groups" sub-model is sent by a Route module to a Station module (Figure 6.15). After that, Batch module (Figure 6.16) allows only the 12% of entities to pass. After that, the entities go to "Negative productivity" Record module.

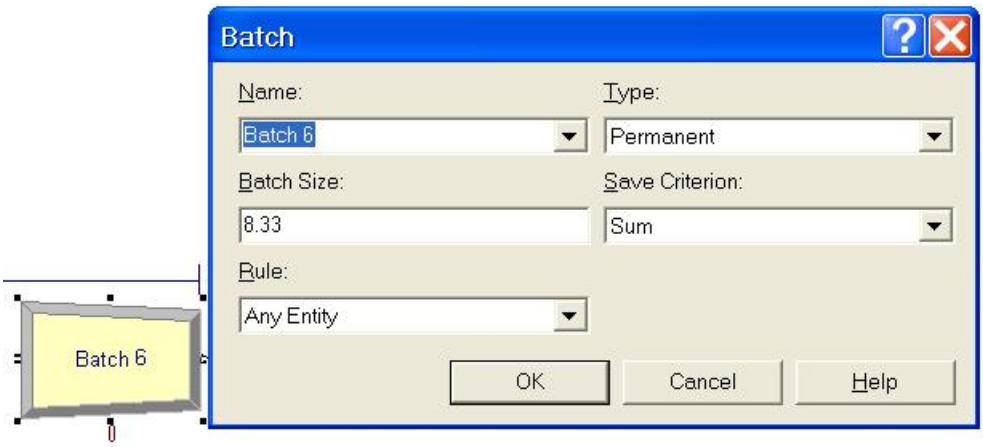


Figure 6.16 Batch module

11- An Assign module (Figure 6.17) with name Assign1 marks the entities which pass from "Positive productivity" Record module by variable 1 with value = +1. After that, entities go to total impact on productivity Record module, see Figure 6.19.

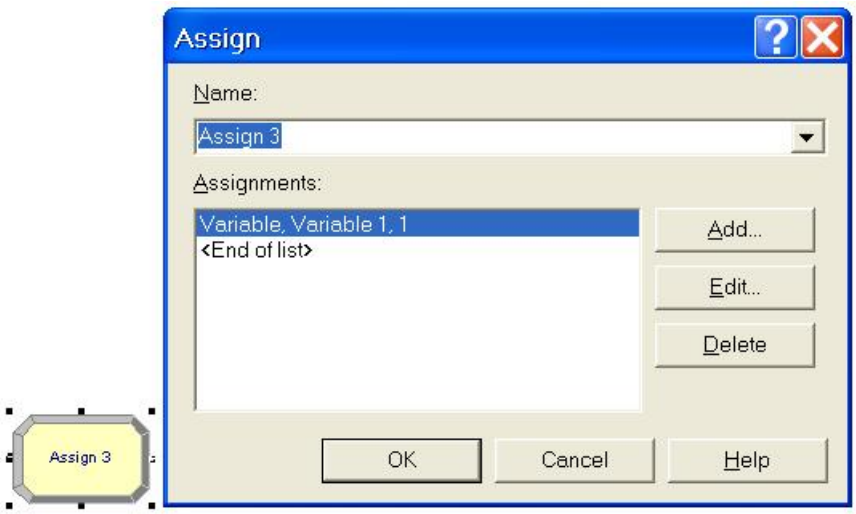


Figure 6.17 Assign module

12- An Assign module with name Assign2 marks entities which pass from "negative productivity" Record module by variable 1 with value = -1. After that entities go to total impact on productivity Record module, see Figure 6.19.

6.7.4 Impact of change orders on project performance part

This part consists of 13 modules (Figure 6.18) and it shows the result of the

simulation model of change orders and their impact on performance.

The first part consists of Station module connected by Dispose module (Figure 6.18). The Station module collects all unneeded entities in the model and sends them to the Dispose module.

The second part consists of a Record module called Total Impact on productivity (Figure 6.19). The Record module receives entities coming from Assign1 and Assign2 modules and adds them together, see Section 6.7.3 Points 11 and 12.

The third part consists of a Station module called Cost (Figure 6.18). The Station module receives entities coming from Route module, see Section 4.7.2 Point 9, and sends them to a Record module called "Total Positive impact on cost". The same thing happens with negative cost (Figure 6.18) and impact on time (Figure 6.18).After running the model, the total impact on cost, time, and productivity will also be generated (Figure 6.20).

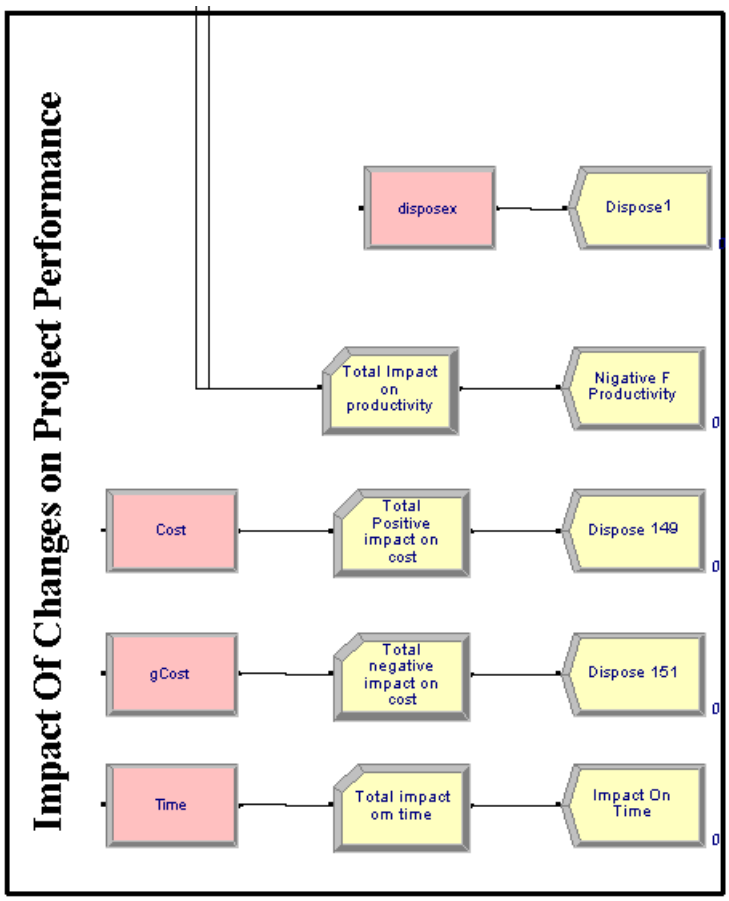


Figure 6.18: Impact of change orders on project performance part

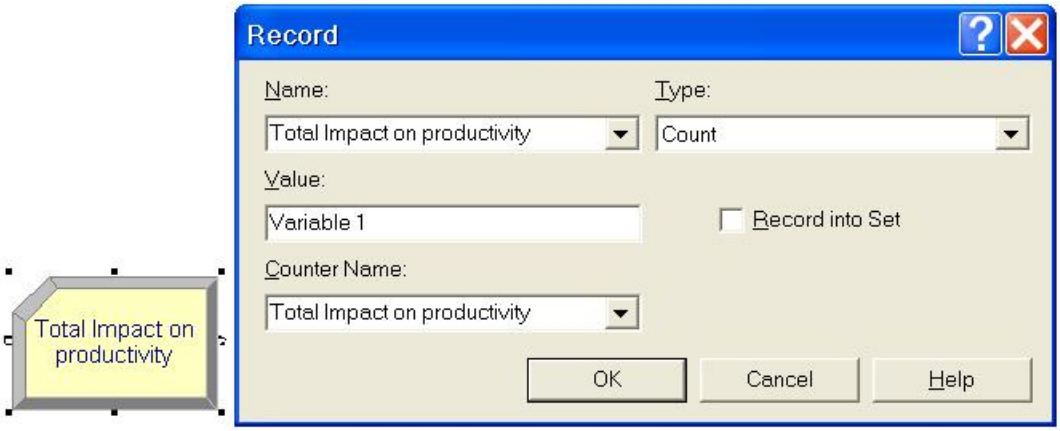


Figure 6.19: Variable counter module

6.8 Using Model

To demonstrate how project parties can use the model, the following systematic steps have be followed:

1- Collect change orders in the respective project, then determine the causing factors from Table 4.1 For each change. For example, suppose there are ten changes in the project and change (1) is caused by [G1(Design Errors), F1(Design errors)]. Changes (2, 3, 4) are caused by [G3(Scope and quantities of work), F21(positive significant changes in the quantities of work)]. Changes (5, 6) are caused by [G3 (Scope and quantities of work), F21(Negative significant changes in the quantities of work)]. Changes (7, 8, 9, 10) are caused by [G9 (Actions by others), F90 (users need)]. The respective service times should be calculated according to Equation 6.1 as demonstrated in step 2. Table 6.7 summarizes the changes and respective occurrences

2- In the previous example F1 occurred once so the service time = $\left(\frac{1}{1}+\frac{1}{2}\right)\times\frac{1}{2}=0.75$.

3- F21positive happened three times, so the service time = $\left(\frac{1}{3}+\frac{1}{4}\right)\times\frac{1}{2}=0.292$.

4- F21negative happened twice, so the service time = $\left(\frac{1}{2}+\frac{1}{3}\right)\times\frac{1}{2}=0.417$.

5- F90 happened four times, so the service time = $\left(\frac{1}{4}+\frac{1}{5}\right)\times\frac{1}{2}=0.225$.

6- The summary of the previous are (G1 F1, T= 0.75), (G3 F21positive, T= 0.292), (G3 F21negative, T= 0.417), and (G9 F90, T= 0.225) see Table 6.8.

7- To operate the model, the following procedure are followed:

   a- Open the model and use only part 2 " Change Orders' Groups"

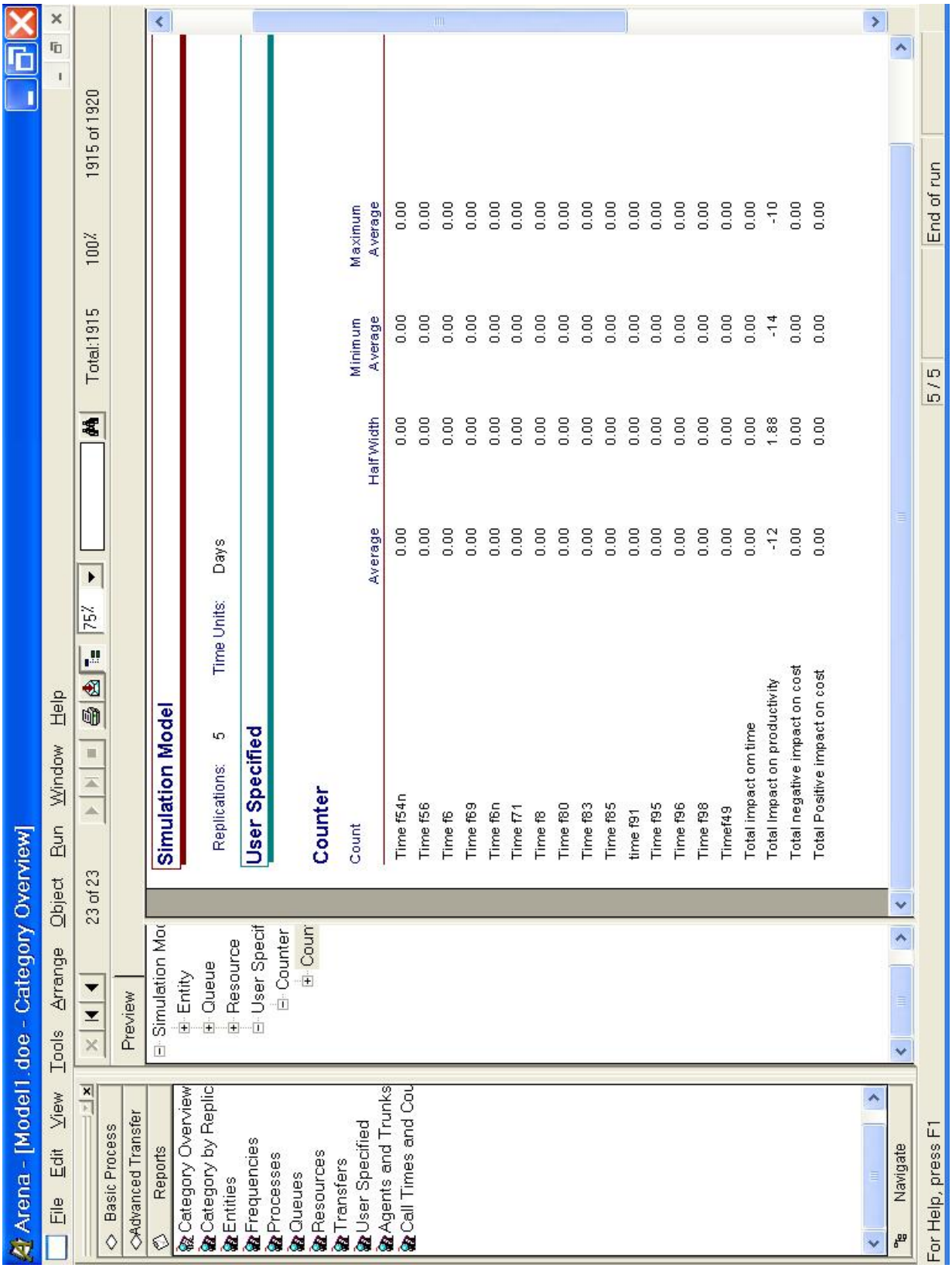


Figure 6.20: Model result

a- Double click on "G1Design Errors" (Figure 6.21)

b- Double click on "F1 Dr " block and put the value of T in the delay value

box (Figure 6.22), then chose ok.

c- Click the right mouse button and chose "close sub-model".

d- Redo (a, b, c, and d) with all factors.

e- Press F5 button then wait until finishing the program then chose yes.

f- The result will be appeared.

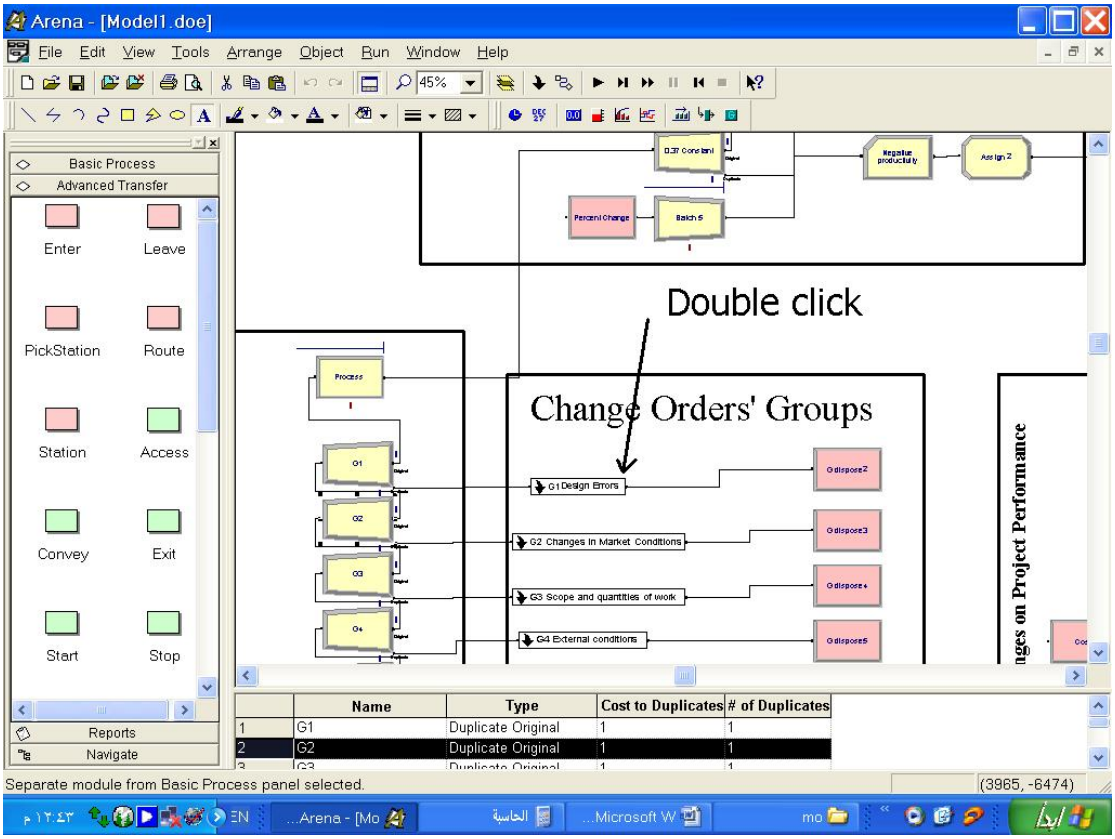


Figure 6.21: Double click on "G1Design Errors"

Table 6.7: Summery of the previous example

Group	Factor Number	Factor Name	Occurrences	Service Time
G1	1	Design errors	1	0.75
G3	21	Positive significant changes in the quantities of work	3	0.292
G3	21	Negative significant changes in the quantities of work)	2	0.417
G9	90	Users need	4	0.225

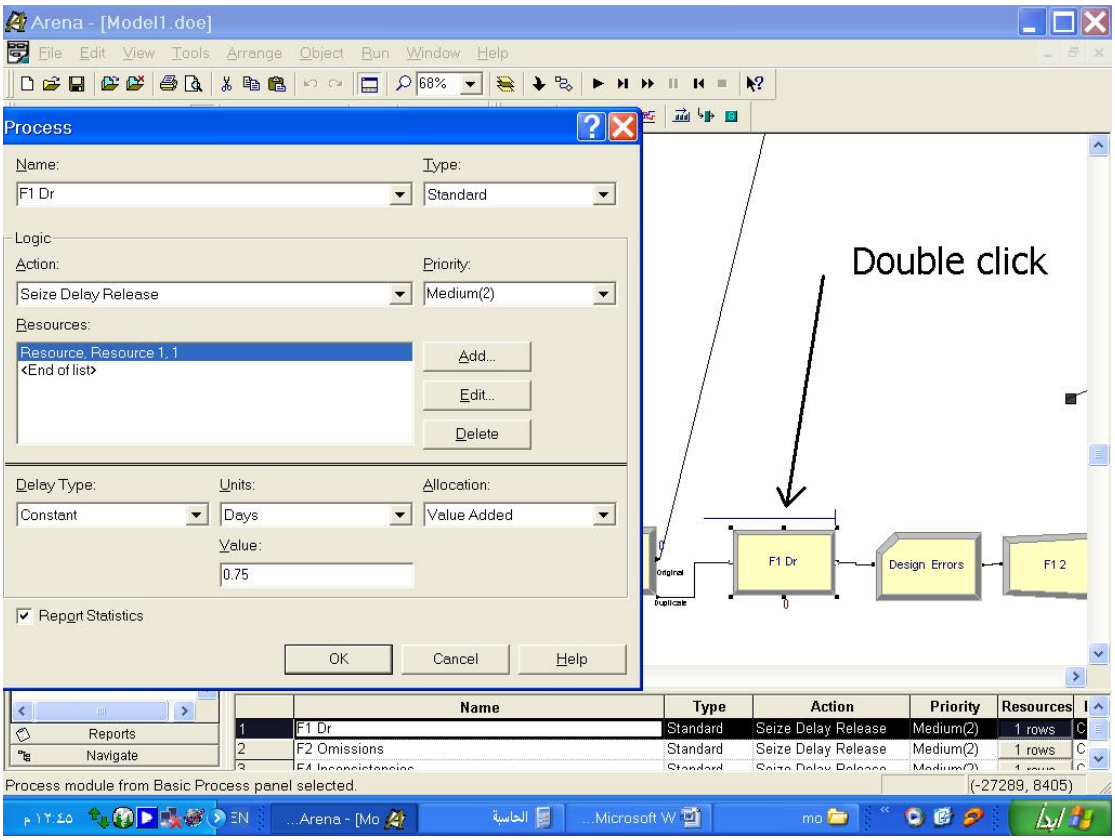


Figure 6.22: Double click on "F1 Dr " block and put the value of T

6.9 Model Verification

Two methods were used to verify the model. The first was by reviewing the model step by step with the supervisor to insure that there was no error in the logic and the second was by inserting the result of each case study on the model and comparing the results.

Thirty two replications were used to analyze the data where these replications were the smallest number of replications which gave the highest maximum of total impact on performance and the lowest minimum of total impact on performance.

To satisfy the verification of increase the cost, decrease in cost and extension in the time, the mean error, the bivariate correlations, and categorical regression were calculated.

Table 6.8 outlines the actual increase in the projects' cost due to change orders and the simulation results. The mean error between the actual increase in cost and the simulated increase is 2.98%, which means the average accuracy of the simulation model in predicting increase in cost was 97.02%. As a result, it can be confidently said that the simulation represents significantly the actual cost increase.

Bivariate correlations factor for the actual increase in cost and the simulated increase (Table 6.9) was 0.889 and it is satisfactory at $\alpha = 0.000$ which means that the test is satisfactory at level of confidence approaching to 100%, that means there is a good relationship between the actual and the simulation results.

Table 6.8: Actual increase and simulated increase in cost

#	Case	Number of changes	Actual increase in cost (%)	Simulated cost increase (%)			
				Min	Max	Mean	Average Error
1	H1	28	34.78	23	45	31.4	3.34
2	H2	28	16.9	9	24	13.8	3.09
3	H3	6	9.01	1	11	4.48	4.53
4	H4	56	13.8	10	31	21	7.2
5	R1	31	9	4	14	9.63	0.63
6	R2	21	8.71	2	17	9.7	0.99
7	R3	2	1.49	0	6	2.31	0.82
8	R4	31	5.96	6	20	13.9	7.94
9	R5	16	10.72	5	15	9.72	1
10	S1	21	12.38	8	26	16.8	4.42
11	S2	16	5.86	1	16	5.93	0.07
12	S3	9	26.41	12	28	21.2	5.21
13	S4	29	18.77	5	27	17.1	1.64
14	S5	36	17.79	6	31	21.5	3.71
15	S6	15	7.71	3	18	7.87	0.16

Table 6.9: Bivariate correlations for actual and simulated increase in cost

Simulation	Actual		
0.889*	1	Pearson Correlation	Actual
0.000		Sig. (2-tailed)	
15	15	N	
1	0.889*	Pearson Correlation	Simulation
	0.000	Sig. (2-tailed)	
15	15	N	

* Correlation is significant at the 0.01 level (2-tailed).

Categorical regression between the actual increase in cost - dependent variable - and the simulated increase – predictors - was done. After That ANOVA test was done. The α value of the ANOVA test was 0.000 which means that the test is satisfactory at a level of confidence approaching to 100%. Categorical regression is satisfactory at α = 0.000 which means that the test is satisfactory at a level of confidence approaching to 100%. which lead to said there are a real relationship between the actual result and the simulation result. Table 6.10, 6.11, 6.12 illustrate the results of the Categorical regression.

Table 6.10: ANOVA test for actual increase and simulated increase in cost

Sig.	F	Mean Square	df	Sum of Squares	
0.000	2113.039	14.908	1	14.908	Regression
		0.007	13	0.092	Residual
			14	15.000	Total

Dependent variable: actual
Predictors: simulation

Table 6.11: Coefficients of categorical regression for actual increase and simulated increase in cost

Sig.	F	df	Standardized Coefficients		
			Std. Error	Beta	
.000	2113.039	1	0.022	0.997	Simulation

Dependent variable: actual

Table 6.12: Correlations and tolerance of categorical regression for actual increase and simulated increase in cost

Tolerance		Importance	Correlations			
Before Transformation	After Transformation		Part	Partial	Zero-Order	
1.000	1.000	1.000	0.997	0.997	0.997	Simulation

Dependent variable: actual

Table 6.13 outlines the decrease in projects' cost due to change orders and the simulation results. The average error between the actual decrease in cost and that of the simulation was 1.114%. This means that the average accuracy of the simulation

model in the prediction of cost decrease was 98.886%. Therefore, it can be truly said that the simulation model represents the actual cost decrease.

Table 6.13: Actual decrease and simulated decrease on cost

serial	Case			Decrease in Cost Simulation			
		Number of changes	Actual decrease in project cost	Min	Max	Mean	Average error
1	H1	28	3.265	0	4	1.47	1.8
2	H2	28	17.2	3	21	11.3	5.86
3	H3	6	0	0	0	0	0
4	H4	56	1.6	2	13	6.6	5
5	R1	31	1.47	0	6	2.75	1.28
6	R2	21	3.77	1	10	3.43	0.34
7	R3	2	0	0	0	0	0
8	R4	31	3.06	0	7	2.88	0.18
9	R5	16	3.19	0	7	2.63	0.56
10	S1	21	0	0	0	0	0
11	S2	16	0	0	0	0	0
12	S3	9	0	0.00	0	0	0
13	S4	29	0.2	0	6	1.6	1.4
14	S5	36	2.51	0	6	2.22	0.29
15	S6	15	0	0	0	0	0

Bivariate correlations factor for the actual decrease in cost and the simulated decrease (Table 6.14) was 0.879 and it is satisfactory at $\alpha = 0.000$ which means that the test is satisfactory at level of confidence approaching to 100%, that means there is a good relationship between the actual and the simulation results.

Categorical regression between the actual decrease in cost - dependent variable - and the simulated decrease – predictors - was done. After That ANOVA test was done. The α value of the ANOVA test was 0.000 which means that the test is satisfactory at a level of confidence approaching to 100%. Categorical regression is satisfactory at $\alpha = 0.000$ which means that the test is satisfactory at a level of confidence approaching to 100%. which lead to said there are a real relationship between the actual result and the simulation result. Table 6.15, 6.16, and 6.17

illustrate the results of the Categorical regression.

Table 6.14: Bivariate correlations for actual decrease and simulated decrease in cost

Simulation	Actual		
.879(**)	1	Pearson Correlation	Actual
0.000		Sig. (2-tailed)	
15	15	N	
1	.879(**)	Pearson Correlation	Simulation
	0.000	Sig. (2-tailed)	
15	15	N	

** Correlation is significant at the 0.01 level (2-tailed).

Table 6.15: ANOVA test for actual decrease and simulated decrease in cost

Sig.	F	Mean Square	df	Sum of Squares	
0.000	148342.619	7.500	2	14.999	Regression
		0.000	12	0.001	Residual
			14	15.000	Total

Dependent variable: actual
Predictors: simulation

Table 6.16: Coefficients of categorical regression for actual decrease and simulated decrease in cost

Sig.	F	df	Standardized Coefficients		
			Std. Error	Beta	
0.000	296685.238	2	0.002	1.000	Simulation

Dependent variable: actual

Table 6.17: Correlations and tolerance of categorical regression for actual decrease and simulated decrease in cost

Tolerance			Correlations			
Before Transformation	After Transformation	Importance	Part	Partial	Zero-Order	
1.000	1.000	1.000	1.000	1.000	1.000	Simulation

Dependent variable: actual

Table 6.18 outlines the increase in the projects' dime due to change orders and the simulation results. The Average error between the actual increase in time and the simulated increase was 4.25%. This means that the average accuracy of the simulation

model in predicting the time impact was 95.75%. This mean that the simulation represents significantly the actual time increase.

Table 6.18: Actual increase and simulated increasing in time

serial	Case			Simulation impact on time			
		Number of changes	Actual impact on time	Project extension time	Max	Mean	error
1	H1	28	8.7	3	14	8.5	0.2
2	H2	28	0	0	0	0	0
3	H3	6	17.5	7	22	12.4	5.1
4	H4	56	6	2	10	5.5	0.5
5	R1	31	16.4	6	20	12.6	3.8
6	R2	21	9.7	6	22	13.3	3.6
7	R3	2	0	0	0	0	0
8	R4	31	8.1	13	29	21.8	13.7
9	R5	16	0	0	2	0.5	0.5
10	S1	21	3.3	3.2	0	7	3.7
11	S2	16	0	0	3	0.2	0.2
12	S3	9	50.00	24	40	31.1	18.9
13	S4	29	3.3	5	27	13.2	9.9
14	S5	36	15.8	10	27	17.8	2
15	S6	15	10	5	20	11.7	1.7

Bivariate correlations factor for the actual increase in time and the simulated increase (Table 6.19) was 0.837 and is satisfactory at $\alpha = 0.000$ which means that the test is satisfactory at a level of confidence approaching to 100%, that means there is a good relationship between the actual and the simulation results.

Categorical regression between the actual increase in time - dependent variable - and the simulated increase – predictors - was done. After That ANOVA test was done. The α value of the ANOVA test was 0.000 which means that the test is satisfactory at a level of confidence approaching to 100%. Categorical regression is satisfactory at $\alpha = 0.000$ which means that the test is satisfactory at a level of

confidence approaching to 100%. which lead to said there are a real relationship between the actual result and the simulation result. Table 6.20, 6.21, and 6.22 illustrate the results of the Categorical regression.

Table 6.19: Bivariate correlations for actual increase and simulated increase in time

Simulation	Actual		
.837(**)	1	Pearson Correlation	Actual
0.000		Sig. (2-tailed)	
15	15	N	
1	.837(**)	Pearson Correlation	Simulation
	.000	Sig. (2-tailed)	
15	15	N	

** Correlation is significant at the 0.01 level (2-tailed).

Table 6.20: ANOVA test for actual increase and simulated increase in time

Sig.	F	Mean Square	df	Squares	
0.000	1658.479	7.473	2	14.946	Regression
		0.005	12	0.054	Residual
			14	15.000	Total

Dependent variable: actual
Predictors: simulation

Table 6.21: Coefficients of categorical regression for actual increase and simulated increase in time

			Standardized Coefficients		
Sig.	F	df	Std. Error	Beta	
0.000	3316.957	2	0.017	0.998	Simulation

Dependent variable: actual

Table 6.22: Correlations and tolerance of categorical regression for actual increase and simulated increase in Time.

Tolerance			Correlations			
Before Transformation	After Transformation	Importance	Part	Partial	Zero-Order	
1.000	1.000	1.000	.998	.998	.998	Simulation

Dependent variable: actual

6.10 Model Validation

Validation of simulation model of change orders and their impact on cost, time, and productivity was validated also in two ways. The first was through two interviews with Palestinian Economic Council projects' managers and the Palestinian Housing Council projects' managers, who expressed their approval of the model. The second was by entering a new case on the model and comparing its results. The case was Khan-Yonis School. Table 6.23 depicts the actual change orders and their actual impact. Table 6.24 compares between the actual and the simulation change orders.

Table 6.23: Actual change orders and their impact on Khan-Younis school

No	GR	Factor Number	Factor	Occurrences	cost impact	Time impact
1	1	1	Design Errors	1	0.02	0
2	1	8	Inadequate Design	3	1.22	0
3	4	42	Extreme whether condition	1		1.33
4	4	44	Israel Closer	1		2.66
5	5	47	Differing Site Conditions	1	6.8	10
6	5	48	Safety considerations	1	0.31	0
7	5	53	Suggestions to Initiate more Quality	4	5.07	0
8	9	87	A prevalent practice on this project and/or district	1	0.78	0
9	9	96	Socio-cultural factors	1	0.02	0

Table 6.24: Comparison between actual and simulated impact of change orders for Khan-Younis school

Case	Number of Changes	Actual Change on Cost	Simulation Impact on cost (%)				Actual Impact on Time	Simulation Impact on Time (%)			
			Min	Max	Mean	Average Error		Min	Max	Mean	Average Error
V1	14	13.99	4	25	11	2.69	13.99	8	28	16.3	2.31

As shown in Table 6.25, the accuracy in predicting cost is 97.31% and the accuracy in predicting time is 97.69%, after entering a new case study into the simulation model. This accuracy means that the simulation model is a significantly valid to be used in the Gaza Strip.

6.11 Model Data Analysis

After building Arena simulation model, all change orders on 15 projects were tested. Table 6.25 illustrates the result of the simulated impact of change orders on cost, time, and productivity where Table 5.18 and 5.19 illustrate the actual .

Table 6.25: Simulated projects results

				impact on cost (%)			Impact on Time (%)		
Serial	Group	Factor	Factor name	Average Min	Average Max	Average Mean	Average Min	Average Max	Average Mean
1	1	1	Design errors	0.00	0.40	0.11	0.00	0.00	0.00
2	1	2	Omissions	0.00	-0.1	-0.02	0.00	0.00	0.00
3	1	4	Inconsistencies	0.00	0.60	0.22	0.00	0.00	0.00
4	1	5	Impossibilities	0.00	0.40	0.13	0.00	0.00	0.00
5	1	6	Change in design request	0.00	0.47	0.18	0.00	0.00	0.00
	1	6	Change in design request	0.00	-0.5	-0.23	0.00	0.00	0.00
6	1	8	Inadequate design	0.73	1.93	1.31	0.00	0.00	0.00
7	1	15	Noncompliance of design with owner's requirements	0.40	1.40	0.81	0.00	0.00	0.00
8	2	18	Specified item became unavailable	0.00	0.20	0.05	0.00	0.00	0.00
9	3	21	Significant changes in the quantities of work	0.67	1.67	1.11	0.00	0.00	0.00

Table 6.26: Simulated projects results (contd.)

				impact on cost (%)			Impact on Time (%)		
Serial	Group	Factor	Factor name	Average Min	Average Max	Average Mean	Average Min	Average Max	Average Mean
	3	21	Significant changes in the quantities of work	0.00	-0.4	-0.17	0.00	0.00	0.00
10	3	27	Plan errors	0.07	0.53	0.28	0.07	0.67	0.31
11	3	29	Change of plans or scope by owner	0.33	1.40	0.98	0.00	0.33	0.08
12	3	31	Change in the owner's requirements	0.00	0.20	0.03	0.00	0.00	0.00
13	3	32	Owner desire to improve his financial conditions	-0.47	-1.53	-1.13	0.00	0.00	0.00
14	4	39	Uncovering disclosed existing conditions	0.00	0.40	0.16	0.00	0.00	0.00
15	4	41	Strikes	0.00	0.27	0.10	0.00	0.00	0.00
16	4	42	Extreme whether condition	0.00	0.00	0.00	0.00	0.40	0.15
17	4	43	Material Unavailability	0.00	0.33	0.11	0.00	0.73	0.35
18	4	44	Israeli closure	0.00	0.00	0.00	4.87	7.93	6.44
19	5	47	Differing site conditions	1.07	2.33	1.65	1.33	2.73	1.87
20	5	48	Safety considerations	0.27	1.07	0.71	0.00	0.60	0.25
21	5	49	Differing subsurface conditions	0.53	1.80	1.07	0.07	0.67	0.40
22	6	52	Suggestions to Initiate more economical construction	0.00	-0.33	-0.14	0.00	0.00	0.00

Table 6.26: Simulated projects results (contd.)

				impact on cost (%)			Impact on Time (%)		
Serial	Group	Factor	Factor name	Average Min	Average Max	Average Mean	Average Min	Average Max	Average Mean
23	6	53	Suggestions to Initiate more Quality	1.80	3.33	2.56	0.00	0.00	0.00
	6	54	Value engineering	0.13	0.67	0.33	0.00	0.20	0.04
24	6	54	Value engineering	-0.3	-1.0	-0.64	0.00	0.00	0.00
25	7	56	Delays in the Project	0.00	0.47	0.21	0.00	0.00	0.00
26	8	69	Consultant's lack of judgment and experience	0.00	0.00	0.00	0.00	0.27	0.09
27	8	71	Honest wrong beliefs of consultant	0.00	0.40	0.22	0.00	0.00	0.00
28	8	80	Contractor's lack of judgment and experience	0.00	0.07	0.00	0.00	0.00	0.00
29	9	83	Utility companies	0.00	0.07	0.01	0.00	0.00	0.00
30	9	85	Local governments	0.00	0.00	0.00	0.00	0.00	0.00
31	9	87	A prevalent practice on this project and/or district	0.47	1.73	1.03	0.00	0.00	0.00
32	9	90	User needs	0.07	0.67	0.33	0.00	0.00	0.00
33	9	91	Review of the project by the proper governmental agency	0.00	0.07	0.02	0.00	0.53	0.28
34	9	95	Change in economic conditions	0.27	1.20	0.67	0.00	0.00	0.00
35	9	96	Socio-cultural factors	0.00	0.20	0.05	0.00	0.00	0.00
36	10	98	Mechanical and electrical provision	0.00	0.20	0.08	0.00	0.00	0.00

Table 6.26: Simulated projects results (contd.)

				impact on cost (%)			Impact on Time (%)		
Serial	Group	Factor	Factor name	Average Min	Average Max	Average Mean	Average Min	Average Max	Average Mean
37	10	100	Technology changes	0.00	0.27	0.06	0.00	0.00	0.00
38	Total Simulation impact on (-) cost			1	3	1.9			
39	Total Simulation impact on (+) cost			8	12	9.75			
40	Total Simulation impact on time			12	16	14.1			
41	Total Simulation impact on productivity			9.00	17.0	13.0			

Simulation analysis show that the total impact of change orders increased the cost on minimum by 8%, average by 9.75%, and maximum by 12%. Total impact of change orders also decreased the cost on minimum by 1%, mean by 1.9%, and maximum by 3%.The total impact of change orders increased the time on minimum by 12%, mean by 14.1%, and maximum 16%. The total simulation impact of change orders decrease the productivity on minimum by 9%, mean by 13%, and maximum by 17%

major factors causing change orders in the Gaza Strip were as follows:

1- Inadequate design caused 19.72% of change orders. It is recommended to involve owners and contractors during the design phase. Consequently any change orders taking place during the construction phase must provide feedback to be taken into consideration in the future.

2- Significant changes in the quantities of work caused 12.68% of change orders. Using experts in preparing bill quantity and reviewing by others will restrain this factor.

3- Suggestions to initiate more quality cased 12.39% of change orders. determining quality level and after that freezing the design against the quality is a good way to restrain this factor.

4- User needs caused 8.45% of change orders. The best way to restrain it is through feedback.

5- Safety considerations caused 6.76% of change orders. The best way to restrain it is through feedback.

6- Owner desire to improve his financial conditions caused 6.87% of change orders. The best way to restrain it is through preparing the feasibility study and studying the financial status during the design phase.

7- Design errors caused 3.94% of change orders. The best way to restrain it is through using expert designers in preparing the design and then the design must be reviewed by other experts.

8- Differing subsurface conditions caused 3.1% of change orders. The best way to restrain it is through doing the soil tests before preparing design.

9- Israeli closures cause 2.54% of change orders. Although most documents stated that the contractors should do their procurement work in the beginning, owners still need to compensate contractors by time so a strategy must be set up so that no damage can be inflicted on the contractors as a result of the Israeli closures.

10- Inconsistencies caused 1.97% of change orders. The best way to restrain it is by using expert designers to prepare the design and then the design must be reviewed by an expert team.

11- Change in economic conditions caused 1.97% of change orders. The best way to restrain it is through conducting an in-depth feasibility study.

12- Differing site conditions caused 1.69% of change orders. The best way to restrain it is by doing an in-depth site investigation.

13- A prevalent practice on this project and/or district caused 1.69% of change orders. The best way to restrain it is by using a form of bill quantity upgraded after every project from feedback.

14- Socio-cultural factors caused 1.69% of change orders. The best way to restrain it is by feedback

15- Noncompliance of design with owner's requirements caused 1.41% of change orders. The best way to restrain it is through involving the owner in design

16- Technology changes caused 1.41% of change orders. The best way to restrain it is through using expert mechanical and electrical engineers and reviewing by other.

Chapter 7

Conclusion and Recommendation

7.1 Conclusion

Change affects every aspect of human endeavors, and construction is not an exception. A recent survey of professional engineers identified change as the major cause of project failure, so a combination of concurrent interviews and case studies were used to collect change orders occurred in 15 building projects and their impact on building projects' performance in Gaza Strip.

As a result of this research, a good tool for showing the factors causing change orders and forecasting their impact on the Gaza Strip building projects have been made available. This tool is a simulation model of change orders and their impact on building projects' performance. The 37 available factors in Gaza Strip (Table 4.2) were modeled in Arena environmental to allow the users to input change orders, then the impact on cost, time, and productivity will appear. The model gave 97.02% accuracy in forecasting the increase in cost, 98.9% accuracy in forecasting decrease in cost, and 95.75% in forecasting time extension.

There were 37 effective factors causing change orders in the Gaza Strip building projects. Those factors caused 355 occurrences of change orders in only 15 projects. These projects encompassed 6 education building projects, 4 health building projects, 5 residential building projects, which were carried out in the Gaza Strip to collect the information required for analysis. The projects which were documented and analyzed were only initiated between 1996 and 2005.

In Gaza Strip, change orders played a significant role in construction because they had a great impact on cost, schedule, and productivity. The simulation analysis showed the following:

1- The Total impact of change orders increased the cost on minimum by 8%, average by 9.75%, and maximum by 12%.

2- The total impact of change orders decreased the cost on minimum by 1%, mean by 1.9%, and maximum by 3%.
3- The total impact of change orders increased the time on minimum by 12%, mean by 14.1%, and maximum 16%.
4- The total impact of change orders decrease the productivity on minimum by 9%, mean by 13%, and maximum by 17%.

The concept of changes in Gaza was unclear, so contractors managed their construction change orders problems without depending on any deep scientific concept. Because of that, this research intended to provide contractors in Gaza Strip with an effective change orders management tool. This tool is a simulation model which explains to contractors how change orders occur and how such orders impact performance. This research added a tool for forecasting the impact of change orders on cost, schedule, and productivity in the Gaza Strip.

7.1.1 Health sector

There were 29 effective factors causing change orders in the health sector in the Gaza Strip. Those factors caused 118 occurrences of change orders in only 4 projects.

The increase in actual cost was: the minimum 9.1%, the maximum 34.78%, and the mean 18.6%. The increase in simulation cost was: the minimum 10.75%, the maximum 27.75%, and the average 17.67%.

The decrease in the actual cost during change orders was: the minimum 0%, the maximum 17.2%, and the average 5.52%. The decrease in simulation cost was: the minimum 1.25%, the maximum 9.5%, and the average 4.84%.

The increase in actual time was: the minimum 0%, the maximum 17.5%, and the average 8.05%. The increase in simulation time was: the minimum 3%, the maximum 11.5%, and the average 6.6%.

The loss in productivity in actual was not measured because there were not any recordings, so (CII,2000) method was programmed in the simulation model and the result of the simulation productivity loss during change orders was: the minimum 9.75%, the maximum 17.75 %, and the average 14.5 %.

7.1.2 Education sector

There were 23 effective factors causing change orders in the educational sector in the Gaza Strip. Those factors caused 135 occurrences of change orders in only 6 projects.

The increase in the actual cost was: the minimum 5.86%, the maximum 26.41%, and the mean 14.82%. The increase in simulation cost was: the minimum 5.8%, the maximum 24.3%, and the average 15.06%.

The decrease in the actual cost during change orders was: the minimum 0%, the maximum by 2.51%, and the mean 0.45%. The decrease in simulation cost were: the minimum 0%, the maximum 2%, and the average 0.63%.

The increase in actual time was: the minimum 0%, the maximum 50%, and the mean 13.7%. The increase in simulation time was: the minimum 7.8%, the maximum 19.5%, and the average 13.5%.

The loss in productivity in actual time was not measured because there was not any document recording the information about the productivity loss so (CII,2000) method was program in the simulation model and the result of the simulation productivity loss during change orders was: the minimum 7.5%, the maximum 17.5%, and the average 13.8 %.

7.1.3 Residential sector

There were 22 effective factors causing change orders in the residential sector in the Gaza Strip. Those factors caused 102 occurrences of change orders in only 5 projects.

The increase in actual cost was: the minimum 1.49%, the maximum 10.72%, the mean 7.18%. The increase in simulation cost was: The minimum 3.4%, the maximum 14.4%, and the average 9.05%.

The decrease in the actual cost during change orders was: the minimum 0%, the maximum 3.77% and the mean 2.3%. The decrease in simulation cost was: the minimum 0.2%, the maximum 6%, and the average 2.34%.

The increase in actual time was: The minimum 0%, the maximum 16.4%, and the mean 6.9%. The increase in simulation time was: the minimum 5%, the maximum 14.6%, and the average 9.6%.

The loss in productivity in actual was not measured because there was not any document recording the information about the productivity loss so (CII,2000) method was program in the simulation model and the result of the simulation productivity loss during change orders was: the minimum 7.4%, the maximum 17.6 %, and the average 13.4 %.

7.2 Problems Encountered

The following problems were faced during this research:

1- All construction projects came to a halt due to the Israeli closure imposed on the Gaza Strip on 14/6/2007.
2- A lot of organizations considered their documents as confidential so they did not permit access to them.
3- There are no records concerning the companies' productivity
4- Israeli airstrikes against all Palestinian ministries led to the loss of most construction projects documents .

7.3 Recommendation

Initially, change orders require more concern regarding managing. Change orders simulation model represents a powerful planning tool that have to be considered, so it is recommended for institutions to have their own model

There were 37 factors causing change orders in Gaza strip causing great impact on cost, time, and productivity so the best way to manage the change orders is by restraining the occurrences of them. Section those factors need to manage. Section 6.11 showed the major factors causing change orders and the way which helps project parties in controlling with their occurrences.

7.4 Further study

It is recommended three different researches be conducted in the future so that each research focuses on each sector separately to satisfy the specialty of each sector so that these developed researches contribute to improvement in construction projects' performance in the Gaza Strip.

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Annex

(1)

Case Studies

Data

Case 1

Project name	community helthcenterin Deir El-Balah
project #	EHRB G2H23. R3. DB.
حدثت إنتفاضة الأقصى أثناء بنائه فقرر تحويله بالكامل لمستشفى	
Duration	18 month
Schedule start date	25/07/1999
Schedule finish date	25/01/2001
start date	15/08/1999
finish date	14/02/2001
Contract Value	1470821 $
final value	1972933.5 $
Owner	Ministry of health
Consultant	Palestinian Economic Council
contractor	Salama Co.
Contractor Strategy	partnering

#	Date	Description	Factor Number	Total COST ($)	Time		Labor Cost ($)
					C. P	non	
1	13/07/1999	اصدار تراخيص بطء	91	500	25		425
2	08/08/1999	للمشروع تغير الشارع و الموقع الخاص	27	1500	7		1245
3		زيادة الحفر ، الردم	49	7530			474.5
4		زيادة حجم خزان الماء للضعف	96	5550			1748
5		أمر تعيين مراقب عمل	8	21600			13608
6		إضافة بند ناقص B40	8	300			36
7		إضافة بند ناقص B7/96,9	8	157			20
8		إنذار حريق إضافة بند ناقص B6/11,12	8	3000			189
9	05/09/1999	أمر بزيادة عدد ساعات الدوام لتعويض تأخير زيادة	56	40000			0
10	11/09/1999	أمر حجر قدسي و العودة عنه ثم استخدامه	69	0	8	38	0
11	11/10/1999	أمر استخدام حجر قدسي بعد اعتماد موازنته	87	140000			4725
12	25/09/1999	أمر تغيير نوع الحجر بعد اعتماد العينة	32	-40000			0
13	20/09/1999	أمر تغيير نوعية ال Water stop	53	800			0
14	25/09/1999	توريد عينة أجود من العقد إصرار المشرف عليها	80	1200			0
15	24/10/1999	تعارض ارتفاعات بعض الأبواب مع السقف المعلق	5	20100			633
16	12/02/2000	أمر إقفال فتحة المصعد بقرميد أحمر	87	1600			302.4
17	23/02/2000	تحديد خصوصية جناح العمليات	15	600			196.8
18	05/10/2000	استبدال الحفر الامتصاصية بشبكة مجاري	54	70830	2	20	17849
19	05/10/2000	رصف الشارع لتسهيل وصول تحول لمستشفى	29	169700	5	50	42764
20	06/10/2000	استبدال سيراميك جدران لقصارة	32	-8010			2018
21	26/04/2000	أمر بتغيير في مجاري التكييف	98.	150			94.5
22		تنفيذ عاكس للأنوار و تحكيم و تبديل فلبس لجاعش	71	2656	0	70	83.6
23	15/07/2000	19 أمر(باب + حوض+إلغاء مغسلة+فاصل+....)	90	9534			1201
24	09/08/2000	تركيب أغطية كوابل	48	800			400
25	15/08/2000	استخدام جرانيت و رخام بدل بلاط للدرج	43	5995			700
26	15/08/2000	أمر تغيير لزوم عيادة أسنان	100	2429.5			1200
27	16/12/2000	إلغاء قاطع SF6 بسعر ومسامحة المقاول به	85				0
28	10/02/2001	أعمال إضافية 4 أوامر	15	5050			600

Case 2

Project name	Zitoon Health Clinic
project #	GZH/11
التأخير بسبب عدد التغيرات و تعاقبها	
Duration	215
Schedule start date	15/10/1996
Schedule finish date	23/06/1997
start date	23/10/1996
finish date	15/07/1997
Contract Value	281007.06
final value	278571.7
Owner	Ministry of health
Consultant	Palestinian Economic Council
contractor	Al Rafe'a Contracting company

#	Date	Description	Factor Number	COST ($)		
				Quantity	Unit Price	Total Cost
1	05/06/1997	الإسفلت بانترلوك استبدال رصفات	53	536.5	8.5	4538.1
2	21/06/1997	الأشعة بالرصاص بدلا من تبطين غرفة القصارة	15	34	115	3350
3	30/06/1997	لطبلونات المياه عمل ضلفات خشب	8	2	70	140
4	07/05/1997	تركيب قرميد أحمر لمدخل العيادة...	87	50.33	70	3523.1
5	30/06/1997	ضلفة ألمونيوم كليل ثابت للمدخل	8	1	140	140
6	05/03/1997	صب خرسانة ميول للسقف و استخدام هيلوكبتر	53	716.5	7.5	5373.7
		إلغاء بند الفوم كنكريت	32	-670	13	-8710
7	30/06/1997	توريد و تركيب لوح بلاستك لباب مدخل الدرج	8	2	50	100
8		شباك ألمونيوم سحاب لغرف الاستقبال	8	4	350	1400
9		تأسيس سقف السطح	8			866
10		باب حديد للدرج	8			400
11		تركيب لمبات خروج الطوارئ	8	2	100	200
12		ردم داخل المبنى	21	1624	3.9	6334.8
13		زيادة خرسانة الأعمدة و السقف لزيادة التأسيس	6			8116.5
14		نقص في خرسانة الجدران الساندة	6	-55.12	175	-9647
15		إلغاء في خرسانات النظافة	32	-22.35	79	-1766
16		إلغاء سدة للكراج	32	9	-25	-225
17		إضافة أعتاب خرسانية للابواب و الشبابيك	8	34.34	250	8585.8
18		إلغاء اجزاء من السور المحيط	32	-240	16	-3840
19		زيادة في كمية البناء الداخلي	21	249.4	9.9	2469.1
20		زيادة في كميات القصارة	21	507	5	2535
21		إلغاء بنود و تخفيض في البلاط و الرخام	32			-2041
22		إلغاء دهان الزيت الخارجي و استبدال دهانات زيت داخلي بسوبركريل	32	-471.7	3.9	-2632
23		استبدال أبواب و شبابيك بأخرى أقل تكلفة	32			-1307
24		إلغاء بند الممشى الجانبي	32	-280	10.5	-2940
25		اعادة تصميم شبكة الصحة	1			411.7
26		توفير في اعمال تشطيب كراج الاسعاف	32			-1450
27		إلغاء بند التكييف و الابقاء على التأسيسات فقط	32			-14220

Case3

Project name	community helthcenterin Deir El-Balah
	انشاء دور اول و اعادة تأهيل الارضي
project #	IDB/WB/074/75-GAZA
Duration	120
Schedule start date	27/01/2003
Schedule finish date	27/05/2003
start date	30/01/2003
finish date	22/07/2003
Contract Value	185885.99
final value	
Owner	Ministry of health
Consultant	Palestinian Economic Council
contractor	Abu Shammala & Abu Dan Co.
Contractor Strategy	تسبب المقاول بتأخير لستخدامه عمالة أقل من المطلوبة للانجاز

#	Date	Description	Factor Number	COST ($)			Time
				Quantity	Unit Price	Total Cost	
1	28/04/2003	البلاط المستخدم أمر تغير نوع	43			2100	7
2	27/04/2003	الغازات بسبب اغلاق المعابر تأخير اعمال	44				14
3	03/04/2003	تخليق مطبخ صغير داخل العناية المركزة للحاجة	90			400	
4	07/05/2003	مجموعة أوامر تغييرية لتحسين غرفة العمليات	15			3500	
5	08/06/2003	وحدات تكييف ضرورية غرفة مرض القلب +العناية+عمليات	15	3	3000	9000	
6		قصارة خارجية زيادة 70%	21			1739.5	

Case 4

Project name	New building C in Nasser Hospital - Khan Younis + Rehabitation
project #	EGSD/156.GZ
Duration	90 days
Schedule start	01/10/2003
Schedule finish	31/12/2003
start date	01/10/2003
finish date	06/01/2004
Contract Value	629350
final value	709400
Owner	Ministry of health
Consultant	Palestinian Economic Council
contractor	El Farra Bros Co.

				COST ($)		
#	Date	Description	Factor Number	Quantity	Unit Price	Total Cost
1	17/05/2004	بند 7.1 و 7.3 استخدام نوع Hamat أو ما يعادله	53			960
2		بند 7.9 تعديل حسب المخططات	4			600
3		بند A7.11 تحديد أطواله	4			480
4		بند 7.13 استبدال الحديد الى ألمونيوم مع محابس فرعية للمخارج	53			1800
5		بند 8.4 زيادة سماكة المواسير زيادة حفر و ردم	1			805
6		كذلك بند 8.6	1			2520
7		بند 8.7 تصحيح	1			3570
8		اضافة أغطية للمناهل	8			1900
9		بند 8.15 استعمال حديد مجلفن بدل الأسود	53			1700
10		بند 8.16 إلغاء اسطوانات الحريق حيث أنها موجودة في بند 8.18	2			-1000
11		بند 8.17 استخدام اسطوانات حريق غاز	48			2500
12		بند 8.18 فصل اسطوانات الغاز عن البودرة	48			150
13		بند 8.11 تحميل برابيش الجولاني على البند	8			600
14		بند 8.19 و 8.20 توصيل العوامات الكهربية مع المضخات	100			800
15		اضافة صندوق حماية للمضخات مع فريم	48			600
16		بندد 8.22 زيادة سماكة المواسير الحديدية	1			350
17		زيادة مواصفات ال diffuser في التكييف	48			2400
18		زيادة كميات في بند 8.31 أكثر من النسبة المتفق بها في العقد	21			2000
19		اضافة توصيلات وحدة غاز أكسجين	8			1100
20		بند 7.5 اضافة مواسير 5.9 ملم	8			800
21		دهان	21	1097	2.5	2743
22		دهان ابواب خشب	21	11	35	385
23		سيراميك جدران	21	158	11	1738
24		جدران جيس	21	-36	15	-540
25		white miniral false ceiling	32	-40	16	-640
26		شبابيك ألمونيوم ألغي البند	32	-20	80	-1600
27		أحواض غسيل	21	71	60	4260

28		طقم حمام	21	29	80	2320
29		خلاط	21	73	50	3650
30		هدم و ازالة مخلفات	21	991	4	3964
31		حوائط بلك 20	21	107	10	1070
32		حوائط 10	21	103	8	824
33		قرميد أحمر	21	53	65	3445
34		طبلون موزع مياه	21	13	150	1950
35		أنابيب جولاني	21	600	2.5	1500
36		كابل 5*16	21	250	5	1250
37		كابل 5*10	21	250	4	1000
38		كابل 5*25	21	50	7	350
39		أنوار فلورسنت	21	7	40	280
40		jet proof	21	30	12	360
41		سويتش	21	25	11	275
42		سويتش	21	20	14	280
43		socket	21	275	12	3300
44		إلغاء البند بالبكامل socket	32	-20	30	-600
45		إلغاء البند بالبكامل socket	32	-15	15	-225
46		إلغاء البند 16*3 c b	32	-20	25	-500
47		e l c	21	5	65	325
48		ci	21	30	5	150
49		step relay (cancel)	32	-3	150	-450
50		cb (cancel)	32	-6	30	-180
51		pipes	21	-550	1.5	-825
52		حفر انابيب	21	-500	1	-500
53		حفر انابيب	21	-362	1	-362
54		باطون جدران استنادية	48	58	110	6380
55		طوب مفرغ للسقف	21	-300	8.5	-2550
56		مجموعة أوامر صيانة غير موجودة بالعقد	47			19389

6 days cusable delay

Case 5

Project name	مدرسة الشجاعية الابتدائية للبنين
project #	EHRP GZE10 R2.GZ
Duration	300 day
Schedule start date	02/11/1996
Schedule finish date	02/09/1997
start date	02/11/1996
finish date	15/09/1997
Contract Value	869278 $
final value	
Owner	Ministry of Education
Consultant	consultant engineering group for modern architecture
contractor	Sadi for contracting & trading
Contractor Strategy	
	Palestinian Economic Council

#	Date	Description	Factor Number	COST ($)			Time
				Quantity	Unit Price	Total Cost	
	24/12/1996	($سيارة من قبل المقاول خصم (50 عدم احضار		220	-50	-11000	
		الموقع غياب مهندس		264	-50	-13200	
1	02/11/1996	مخطط الموقع العام مع أرض الواقع عدم تطابق	27			0	10
2		(s 96 /a 18) الأعتاب الدنيا حزام الارتفاع حتى	1			2500	
3		توضيح موقع شبابيك 9 و الكمية مضاعفة في جدول الكميات	4	54	100	5400	
4	10/12/1996	أمر تسريع لتعويض التأخير الناتج عن الامر الاول	56			0	-3
5	09/12/1996	زيادة كمية الحفر	49	1284	5	6420	
6	10/12/1996	اضافة السور للأرض بجانب المسجد	39			3400	
7	20/12/1996	كمية الردم بلغت زيادة	49	1547	3.3	5103.7	
8	01/03/1997	عمل لوحة فرعية أخرى	1			500	
9	26/02/1997	تنفيذ relay impuls و عدد من المفاتيح الضاغطة	8			150	
10	26/02/1997	وضع مفتاح قوة في للجدار للخلفي لكل صف (لأجهزة العرض)	90	104	10	1040	
11	26/02/1997	استخدام لمبات مزدوجة بدلا من المفردة في الصفوف	53	219	45	9855	
12		اضافة عاكس لكشاف السبورة	53	52	40	2080	
13		توريد و تركيب عدد 6 كشافات صوديم 400 وات	31	6	200	1200	
14	26/02/1997	اضافة جهاز امبليفير	8	1	350	350	
15	18/03/1997	بمنطقة الدرج بناء حوائط	8			3000	
16	18/03/1997	الواجهة حيث بداية الدرج من اليمين خطأ برسم	1	0	0	0	
17	18/03/1997	عمل فواصل تمدد للسقف + مانع تسرب ماء	8	139	10	1387.3	

18	19/05/1997	خط صرف صحي بطول 300م قطر 8 انش	39			10500	
19	26/05/1997	استبدال ممرات الاسفلت ب انترلك	53	970	16	15520	
20	08/06/1997	نقل باب المندرسة	90			500	
21	29/03/1997	بناء جدار أخر عند فواصل التمدد	8	80	36	2880	
22		اعمال تسوية	49	1453	6.7	9735.1	
23		تركيب باب حديدي لدورات	48	1	150	150	
24	03/06/1997	اضافة بانيل للدرج	8	158	3.3	522.72	
25	03/06/1997	مازايكو ممرات	8	284	14	3981.6	
26	03/06/1997	سبورات	8	30	70	2100	
27	04/08/1997	تعديل الجدار الساند بين المدرسة و قطعة الأرض المجاورة	39			2660	
28	06/09/1997	استبدال خط المياه+ مطبخ ادارة + مطبخ كنتين + مطبخ خارس	8			2600	
29	10/09/1997	اعمال رخامية	35	17	40	680	
30	27/07/1997	عمل لوحة من الجرانيت باسم المشروع	90	1	100	100	

Case 6

Project name	sheikh Radwan school
project #	EHRP GZE05 R2.GZ
Duration	300 day
Schedule start date	02/11/1996
Schedule finish date	02/09/1997
start date	02/11/1996
finish date	02/09/1997
Contract Value	869278 $
final value	
Owner	Ministry of Education
Consultant	consultant engineering group for modern architecture
contractor	Shehab for contracting & trading
Contractor Strategy	
	Palestinian Economic Council

#	Date	Description	Factor Number	COST ($)		
				Quantity	Unit Price	Total Cost
	21/11/1996	سيارة من قبل المقاول خصم (50 عدم احضار$)		19	-50	-950
1	18/03/1997	بمنطقة الدرج بناء حوائط	8			3000
2	18/03/1997	الواجهة حيث بداية الدرج من اليمين خطأ برسم	1			150
3	18/03/1997	بناء الدرج من الجهة الخارجية لسلامة الطلاب	48			1200
4	18/03/1997	عمل فواصل تمدد للسقف + مانع تسرب ماء	8	139	10	1387.3
5	01/03/1997	عمل لوحة فرعية أخرى	1			500
6	26/02/1997	تنفيذ relay impuls و عدد من المفاتيح الضاغطة	8			150
7	26/02/1997	وضع مفتاح قوة في للجدار للخلفي لكل صف	90	104	10	1040
8	26/02/1997	استخدام لمبات مزدوجة بدلا من المفردة في الصفوف	53	219	45	9855
9		اضافة عاكس لكشاف السبورة	53	52	40	2080
10		توريد و تركيب عدد 6 كشافات صوديم 400 وات	31	6	200	1200
11	26/02/1997	اضافة جهاز امبليفير	8	1	350	350
12	03/06/1997	اضافة بانيل للدرج	8	158	3.3	522.72
13	03/06/1997	مازايكو ممرات	8	284	14	3981.6
14	03/06/1997	سبورات	8	30	70	2100
15	26/05/1997	استبدال ممرات الاسفلت ب انترلك	53	1455	16	23280
16	27/07/1997	عمل لوحة من الجرانيت باسم المشروع	90	1	100	100

Case 7

Project name	توسعة مدرسة الكرمل
project #	
Duration	6 month
Schedule start date	24/11/2002
Schedule finish date	24/05/2003
start date	24/11/2002
finish date	21/08/2003
Contract Value	209950
final value	237190.52
Owner	Ministry of education
Consultant	Palestinian Economic Council
contractor	Alemran palestinian group co

#	Date	Description	Factor Number	Cost ($)	Time
1		لعلاج فرق منسوب اضافة بدروم	47	27321	45
2	15/03/2003	اعمال سور استنادي+ سور بلك	47	13760	
3		حديدية تركيب بوابة	48	400	
4		شبابيك امامية للبدروم	47	210	
5		تبليط بانترلوك بدلا من الاسفلت	53	7600	
6		قصارة مع الرشقة للسور الاستنادي + مشارب	47	1700	
7		زيادة في كمية الحفر وعمل احلال تربة	49	3701.2	
8		امر تمديد المدة 45 يوم بسبب الظروف الامنية و الاغلاق	44		45
9		احلال	49	746.88	

Case 8

Project name	Khalid Bin Al Waleed School
project #	EHRP. GZE/13. R3. NS.
مهندس موقع جديد و مدير مشروع 10%	
Duration	300
Schedule start date	08/06/1997
Schedule finish date	04/05/1998
start date	08/07/1997
finish date	11/05/1998
Contract Value	716573 $
final value	
Owner	Ministry of Education
Consultant	Palestinian Economic Council
contractor	Al Hallaq Co.
Contractor Strategy	

#	Date	Description	Factor Number	COST ($)			Time
				Q	Unit Price	Total Cost	
1	08/01/1998	أعمال تأسيس المختبر عما بالمخططات تغيير في	87			1000	
2	28/07/1997	الأبعاد بين محاور الأعمدة و الغرف عدم تطابق	4			150	
3	09/08/1997	بسبب الاغلاق و عدم توفر الاسمنت توقف العمل	44				10
4	06/11/1997	زيادة مساحة المظلة	53			3400	
5	09/09/1997	تغيير مكان الملعب و تكبيره	53			5780	
6	10/09/1997	تنفيذ رشقة للسور	53	1700	2.5	4250	
7	16/09/1997	صب الكشفات ملساء مع حساب القصارة حسب الوجه الاملس	53			400	
8	14/09/1997	صب الاحزمة باسمنت مكيس بدل السائب	43	62	5	310	
9	27/10/1997	تبليط المساحة بين الأبنة بالانترلك8+6سم	53	2960	13.6	40256	
10	21/09/1997	بلاط انتر لك للممر بالانترلك 8 سم	53	860	13	11180	
11	29/09/1997	عمل جدار استنادي	49			43360	
12	30/09/1997	استبدال ارضية المظلة من خرسانة لانتراك	53			1400	
13	17/12/1997	استبدال البوابات الحديدية العادية بمنزلقة	53	2	150	300	
14	20/12/1997	تزويد المختبر بطاولات نصف الحجم بنفس السعر	5			550	
15	23/12/1997	فصل دورات المدرسين عن المدرسات فصلا تاما و تنفيذ ما يتطلب	96			700	

16		دهان بوية خضراء لشبابيك الحماية	8			1532.5	
17		فرش كركار أسفل بلاط المقصف و المخزن و غرفة الحارس بدل البيسكورس	32	88	-2	264	
18		فرش كركار لملعب كرة السلة بدل البيسكورس	32	580	-2	-1160	
19		فرق سعر لتركيب برج كرة السلة من الفبر بدلا من الخشب	53	2	250	500	
20		تركيب مرمى كرة يد	8			466	
21		فرش بيسكورس 15 سم لطريق سيارات	8	516	3	2580	
22		عمل مزراب كياه مجلفن للمظلة	8	1	500	500	
23		زيادة كمبات الحفر	49	5554	2	11108	
24	24/02/1998	أمر تغيير اللون من السكني للكريم	90			413.3	
25		تركيب شباكين مخزن	1			400	
26		تركيب أبواب سطج حديد مجلفن	8	3	250	750	
27		تركيب خزان للمشربيات	96			250	
28		تركيب بوابة عرض 4متر بدلا من 3	53			150	
29		تركيب غطاء مضخة + عجلات + شبك+صواري	8			2790	

Case 9

Project name	Nusairat Girls Bisic School
project #	EHRP. GZE/07. R3. NS.
Duration	300
Schedule start date	08/01/1997
Schedule finish date	04/11/1997
start date	08/01/1997
finish date	17/11/1997
Contract Value	856439
final value	
Owner	Ministry of Education
Consultant	Palestinian Economic Council
contractor	Al Hallaq Co.
Contractor Strategy	

#	Date	Description	Factor Number	COST ($) Q	Unit Price	Total Cost	Time
1	17/02/1997	لتحمل قوى الزلازل ل زيادة التسليح B18	8			6000	
2	23/03/1997	تمدد عمل فواصل	8			1050	
3		نقص في خرسانة النظافة	52	66	-105	-6930	
4		زيادة خرسانة الجسور	21	37.9	160	6064	
5		تقليل بناء حجر بلدي راس تحت الحزامات الأرضية	52	-50.34	15	-755.1	
6		نقص في كمية الحجر المفرغ	21	-954	12	-11448	
7		زيادة في القصارة الخارجية	21	1640	5	8200	
8		كذلك رشقة	21	648	3	2124	
9		دهان	21	1381	3	4143	
10		مزايكو أسفل الأبواب	21	27	9	243	
11		سيراميك جدران	21	36.5	20	730	
12		شبكة صرف صحي	47			5900	
13		زيادة كمية اسفلت	21			8127	
14	25/10/1997	أمراستبدال اسفلت بانترلك	53	1445	14	20225	
15		تركيب سبورات	8	30	105	3150	
16		أمر تركيب مزايكو للممرات	8	276	14	3863.7	
17		اغلاق	44				8
18		توقف عمل	42				4
19		تركيب مازايكو لزوم درابزين	8	85.96	10	859.6	
20		تركيب جرانيت تايجر	53	11.9	150	1785	
21		رخام محلي	53	20.8	40	832	
22		رخلم محلي	53	7.4	10	74	
23		حواشي درجات	8	157.	3	471.24	

				1			
24		عمل غرفة حارس	87			5296	
25		تركيب كابل 5*6 مع لوحة مع ريلي	98			1010	
26		تركيب أنوار للسبورات	53	52	45	2340	
27		أيدي لأبواب الحمام	8	28	3	84	
28		مضخة مياه	8			150	
29	08/03/1997	عمل مواسير صرف بدلا من المسار المكشوف	49	500	100	50000	
30		عمل بانيل للدرج	53	95	4	380	
31		تغيير في حجم شبابيك الدورات	96			200	
32		تركيب دربزين خاص بالممرات	48	33	32	1056	
33		استبدال حديد الحماية بمجلفن	53			16745	
34	28/09/1997	تحويل البوابات لمنزلقة	53	400	2	400	
35		عمل بفيه للادارة و الكنتين و غرفة الحارس	90			900	
36		استبدال طبقات البيسكورس بكركار	52			-2400	

Case 10

Project name	Qezan Alnajar Kan Younis School
project #	EHRP. GZE/09. R4-KY
Duration	300
Schedule start date	25/01/1997
Schedule finish date	21/11/1997
start date	25/01/1997
finish date	10/12/1997
Contract Value	735280.5
final value	
Owner	Ministry of Education
Consultant	Palestinian Economic Council
contractor	Al-Farra Co.
Contractor Strategy	

#	Date	Description	Factor Number	COST ($)			Time
				Q	Unit Price	Total Cost	
1	22/02/1997	في القواعد و الأعمدة نعديل الحديد	1			150	
2		خطاً بالشبكية و مناسيب الارض	1			900	
3	28/03/1997	أمر تركيب سبورات	8			5085	
4		غرفة حارس	87			5735	
5		اغلاق	44				8
6		توقف بسبب سوء الجو	42				4
7		عمل فواصل التمدد	8		105	1050	
8		عمل بانيل للدرج	53	95	5		
9		تغيير في حجم شبابيك الدورات	96			200	
10	03/06/1997	استبدال أعمال الألومنيم من كليل 1920 ل 1700	18			1200	
11		استبدال حديد الحماية بمجلفن	53			16745	
12		تركيب درابزين للممرات	48	30	75	2250	
13		تركيب مزايكو للبلكونات	8	200	14	2800	
14	25/10/1997	تركيب انتر لك	53	1367	13	17771	
15		تركيب أنوار للسبورات	53	52	45	2340	

Case 11

Project name	Constructing Housing Building – Engineering institute - Rafah
project #	2/2005
Duration	12 month
Schedule start date	22/04/2006
Schedule finish date	21/04/2007
start date	22/04/2006
finish date	14/06/2005
Contract Value	706965.49
final value	744174.2
Owner	Palestinian Housing council
Consultant	Al-Manama
contractor	Salah Al-Deen Co.
Contractor Strategy	

#	Date	Description	Factor Number	COST ($)			Time
				Q	Unit Price	Total Cost	
1	31/05/2006	زيداة الأسقف تغيير المبنى	27			25665	
2	31/05/2006	الكركار زيادة	4	122	3	366	
3	31/05/2006	تقليل سمك حائط المصعد وزيادة تسليحه	83			123.8	
4		تغيير قطر الكواسير أسفل البلاط من 3 ل 2 انش	52			-4000	
5		تبديل بلك 20 ب 15 لدواعي معمارية دون سعر	4			0	
6		تعديل الكمرات بين الأعمدة لضمان توزيع أحمال و اضافة حزام	1			100	
7		استبدال أبواب 160 ب 80 في للبلكونات	32	34	-100	-3400	
8	08/07/2006	اغلاق	44			0	58
9		عمل بلاط انترلوك حول المبنى	53	300	14	4200	
10	09/12/2006	تبديل حلق الباب بدل 13 ب 18	5	60	10	600	
11	04/12/2006	نقل صندوق الكهرباء	48	2	325	650	
12		ملء فواصل التمدد بعزل و الومنيوم	8	43	12.5	537.5	
13		بناء غرفة للمولد بدلا من الشبك	53			3500	
14	24/06/2007	اضافة سور للمشروع	48			10000	
15		تركيب علب تفتيش للبلاكين	8	34	14	476	
16		خطوط تغذية و تصريف غسالة	8			1908	
17		زيادة السيب الحديدية	48			3177	
18		شبابيك للمصاعد	90			195	
19		باب درج حديدي	8	2	200	400	
20		رخام بلاكين	8	155	8	1240	
21		change over	100	2	537.5	1075	
22		تشغيل الي للمولد	100			1208	
23		تشغيل الي للعومات المياه	100			600	
24		مواسير 4 انش للكهرباء	8			1419.5	

25		مواسير 3 للتلفونات و مناهل	8			405	
		تغيير خرسانة الاسقف	32			-2400	
		إلغاء خزانات حريق	32			-600	
		ابواب مناور كهرباء	8	51	70	3570	
		درجات مزايكو حواف كسر رخام	8	10.3	13	133.9	
		تركيب باب حديد	8	5	300	1500	
		اغطية صاج للمناور	8			600	

Case 12

Project name	Constructing Housing Building – Al-Rakaba instetute
project #	3/2002
Duration	12 month
Schedule start date	23/04/2003
Schedule finish date	22/04/2004
start date	23/04/2003
finish date	
Contract Value	477334
final value	473069.1
Owner	Palestinian Housing council
Consultant	Jenena
contractor	Al- Shehabia
Contractor Strategy	

#	Date	Description	Factor Number	COST ($)			Time
				Q	Unit Price	Total Cost	
1	24/04/2003	للتربة عمل احلال	49			4679	10
2	27/05/2003	البلدية بدعوى عدم وجود ترخيص توقيف من قبل	91				1
3	31/05/2003	تنفيذ عزل للقواعد و الرقاب	8			400	
4	13/08/2003	عمل نوافذ للشقق الشرقية اضافية	90	14	100	1400	
5	04/10/2003	أمر تقطيع داخلي بعد خلاف	71	850	17.5	14875	
6		تغيير نوع المصاعد	54	2	-9000	-18000	
7		أعمال عزل للسقف الأخير و الميول	8			6743	
8		عمل باب بين المظلة و المبنى	90			300	
9		تركيب ابواب بعض الشقق ملتي لك بدلا من خشب	90	5	500	2500	
10		تنفيذ ممر معلق للمدخل	53			3455.2	
11		عمل تبليط انترلك للممر الخارجي	90	50	16	800	
12		اضافة كنار للدرج	8			486	
13		استبدال دهان الزيت للدرج بتمبر تكس	53			300	
14		اغلاق	44				24
15		دهان المظلة بالزيت بدلا من السوبر كريل	53			254	
16		تركيب حوامل لبراميل المياه	53	8	210	1680	
17		انشاء منحدر للبرج	48			2185	
18		تركيب دربزين للممر	8			736	
19		مزايكو	8			253.5	
20		عمل قاعدة للمولد	48			81	1
21		عمل حزام للممر الغربي	48			440	14

Case 13

Project name	Constructing Housing Building – Rafah
project #	1/2002
Duration	8 month
Schedule start date	05/07/2002
Schedule finish date	04/03/2003
start date	05/07/2002
finish date	04/03/2003
Contract Value	276879.5
final value	281174.5
Owner	Palestinian Housing council
Consultant	Door
contractor	Salah Al-Deen Co.
Contractor Strategy	

#	Date	Description	Factor Number	COST ($)			Time
				Q	Unit Price	Total Cost	
1		قصارة و دهان و زجاج إعادة أعمال	41			3835	
2		حماية للدرج تركيب حديد	48			292.4	

Case 14

Project name	Constructing Housing Building – Tal Alhow
project #	1/2003
Duration	8 month
Schedule start date	14/12/2003
Schedule finish date	14/12/2003
start date	13/08/2004
finish date	19/05/2005
Contract Value	587528
final value	604561
Owner	Palestinian Housing council
Consultant	Yafa
contractor	Bonian
Contractor Strategy	Claimer

#	Date	Description	Factor Number	Total Cost	Time
1	23/03/2004	للحد الشرقي للحفر تدعيم خاص	49	7365	4
2	07/09/2004	انشاء منحدر	48	2185	
3	27/09/2004	استبدال الزجاج بمثلج	96	1300	
4	27/09/2004	تغيير لون البرج	90	1200	
5	27/09/2004	عمل تمديدات للحمامات الشمسية	90	1500	
6	14/10/2004	فتح باب حديدي بين الممر و المظلة	8	580	
7	23/11/2004	عمل سقف مصعد مغع احزمة	8	1082	
8	25/11/2004	عمل تأسيسات لفتحة شفاط	8	1200	
9		عمل حوائط ساندة	4	147	
10	15/01/2005	تغيير نوع المصاعد من كوني لشلندر	54	-18000	
11	01/02/2005	تغييرات داخلية بالشقق	90	47.6	
12	01/02/2005	تغييرات داخلية بالشقق	90	297	
13	01/02/2005	تغييرات داخلية بالشقق	90	117	
14	01/02/2005	تغييرات داخلية بالشقق	90	325	
15	01/02/2005	تغييرات داخلية بالشقق	90	245	
16	01/02/2005	تغييرات داخلية بالشقق	90	47.6	
17	01/02/2005	تغييرات داخلية بالشقق	90	297	
18	01/02/2005	تغييرات داخلية بالشقق	90	89	
19	01/02/2005	تغييرات داخلية بالشقق	90	108.5	
20	15/01/2005	اغلاق جزئي(2005/2/5 - 2005/1/15)	44		11
21	06/02/2005	اغلاق كلي(2005/2/6/ - 2005/2/16)	44		11
22	27/02/2005	اضافة أربع براميل مياه	95	2200	
23		تركيب شبكة اسود مياه	95	9000	
24		وضع رمل بالشقق	95	2800	
25		باب خشب لغرفة الكهرباء	8	170	
26		قصارة خارجية	21	1952	
27		دهان خارجي	21	97.6	
28		دربزين درج	21	169	
29		زيادة عرض بلاطة الرخام المستخدم من 17 ل 23	53	100	
30		تركيب شفاط كهربي للمولد	21	334	
31		دريزين ممر	48	78	

Case 15

Project name	Constructing Housing Building – Dewan Almothafeen
project #	1/2005
Duration	8 month
Schedule start date	20/04/2005
Schedule finish date	19/12/2005
start date	20/04/2005
finish date	10/01/2006
Contract Value	564475
final value	593254
Owner	Palestinian Housing council
Consultant	Dar Al-Handasa
contractor	Hatawee Co.
Contractor Strategy	

#	Date	Description	Factor Number	COST ($)			Time
				Q	Unit Price	Total Cost	
1	25/04/2005	المدخل و المظلة تعديل مناسيب	1			1100	
2		أخر للبدروم عمل مدخل درج	90			3000	
3		تعلية ارتفاع البدروم	90			900	
		تبديل نوع المصعد من كوني لشلندر	54			-18000	
4	31/05/2005	عزل حواءط البدروم	8			1060	
5	23/07/2005	عمل باب حديد سحاب لمدخل البدروم	48			660	
6	03/09/2005	نقل أعمال بلك المظلة لجهة أخرى و تحويلها صالة (رخام+ شبابيك)	90			600	
7	12/10/2005	عمل شبابيك حديد شرائح	48			360	
8	01/12/2005	حبسات مزايكو لزوم المظلة	90			440	
9		اضافة القصارة لأعمال البناء	95	14400	2.7	38880	
10	26/12/2005	حماية المنطقة الشرقية مع الجار	48			1400	
11		توريد و تركيب حلوق أبواب خشبية	95	33	224	7392	
12		تأسيس سقف الدور السادس	90			340	
13		تركيب خزانات علوية و تغيير مقاسها و طريقة التركيب	95			700	
14	02/01/2006	تغيير طريقة تأسيسات الصحة	53			200	
15		عمل بلاط انترلك للمدخل	95			3500	

case T

Project name	Kan Younis School
project #	EHRP. GZE/09. R5-KY
Duration	300
Schedule start date	25/01/1997
Schedule finish date	21/11/1997
start date	25/01/1997
finish date	24/12/1997
Contract Value	735310.5
final value	
Owner	Ministry of Education
Consultant	Palestinian Economic Council
contractor	Al-Salama Co.
Contractor Strategy	

#	Date	Description	Factor Number	COST ($)			Time
				Q	Unit Price	Total Cost	
1	22/02/1997	في القواعد و الأعمدة نعديل الحديد	1			160	
2	28/03/1997	أمر تركيب سبورات	8			5100	
		ازالة خط المجاري	47			50000	30
3		غرفة حارس	87			5800	
4		اغلاق	44				8
5		توقف بسبب سوء الجو	42				4
6		عمل فواصل التمدد	8		105	1050	
7		عمل بانيل للدرج	53	95	5	475	
8		تغيير في حجم شبابيك الدورات	96			200	
9		استبدال حديد الحماية بمجلفن	53			16745	
10		تركيب درابزين للممرات	48	30	75	2250	
11		تركيب مزايكو للبلكونات	8	200	14	2800	
12	25/10/1997	تركيب انتر لك	53	1367	13	17771	
13		تركيب أنوار للسبورات	53	52	45	2340	

Annex

(2)

Case Studies

Summary

Case 1: Deir El-Balah Hospital

This project was a community health center in Deir El-Balah, but because the occurrence of El-Aqsa Intifada the community center changed to a hospital.

The owner of this project was the Ministry of Health and the contract type of this project was a unit price contract and the strategy of the contractor was a partnering strategy. The duration of this project was 18 months and the schedule starting date was 25/07/1999 and the actual starting data was 15/08/1999. The delay in project was 19 causable days with finishing date on 14/02/2001. The contract value was 1470821$, but the contract close up cost was 1972933.5$. The relationship between the contractor, consultant, and owner was a good one.

Percentage of time that the project manager spent on the project was not less than 95% and percentage of change orders initiated by the owner was 56% with 75% productivity (Table 2.2) for the project. Table 1 summarizes the results of change orders and their impact on performance.

Table 1: Summary of Deir El-Balah hospital

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
9	91	Review of the project by the proper governmental agency	500	25	425
3	27	Plan errors	1500	7	1245
5	49	Differing subsurface conditions	6030	0	380
5	49	Differing subsurface conditions	1500	0	94.5
9	96	Socio-cultural factors	5550	0	1748.5
1	8	Inadequate Design	21600	0	13608
1	8	Inadequate Design	300	0	36
1	8	Inadequate Design	157	0	20
1	8	Inadequate Design	3000	0	189
7	56	Delays in the Project	40000	0	0
8	69	Consultant’s lack of judgment and experience	0	8	0
9	87	A prevalent practice on this	140000	0	4725

		project and/or district			
3	32	Owner desire to improve his financial conditions	-40000	0	0
6	53	Suggestions to Initiate more quality	800	0	0
8	80	Contractor's lack of judgment and experience	1200	0	0
1	5	Impossibilities	20100	0	633
9	87	A prevalent practice on this project and/or district	1600	0	302.4
1	15	Noncompliance of design with owner's requirements	600	0	196.8
6	54	Value Engineering	70830	2	17849
3	29	Change of plans or scope by owner	169700	5	42764
3	32	Owner desire to improve his financial conditions	-8010	0	2018
10	98	Mechanical and electrical provision	150		94.5
8	71	Honest wrong beliefs of consultant	2656	0	83.6
9	90	User needs	9534	0	1201
5	48	Safety considerations	800	0	400
4	43	Material non- availability	5995	0	700
10	100	Technology changes	2429.5	0	1200
1	15	Noncompliance of design with owner's requirements	5050	0	600
Total		28	463571.5	47	90513.3

Case 2: Al-Zaitoon Health Clinic.

This project was a health clinic in Al-Zaitoon in Gaza . The owner of this project was the Ministry of Health. The contract type of this project was a unit price and the duration of this project was 215 days with schedule starting date

on15/10/1996 but the actual starting on 23/10/1996. The delay of this project was 14 causable days with the finishing date on 15/07/1997. The contract value was 281007.06 $, but the contract close up cost was 278571.7 $. The relationship between the contractor, consultant, and owner wasn't a good one.

Percentage of time the project manager spent on the project was not less than 95% and the percentage of change orders initiated by the owner was 10.2% with 75% productivity (Table 2.2) for the project. Table 2 Summarizes the result of change orders and their impact on performance.

Table 2: Summary of Al-Zitoon Health Clinic

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
6	53	Suggestions to Initiate more Quality	4538		286
1	15	Noncompliance of design with owner’s requirements	3350		111
1	8	Inadequate Design	140		15
9	87	A prevalent practice on this project and/or district	3523.1		230
1	8	Inadequate Design	140		10
6	53	Suggestions to Initiate more Quality	5373.7		1650
3	32	Owner desire to improve his financial	-8710		
1	8	Inadequate Design	100		10
1	8	Inadequate Design	1400		10
1	8	Inadequate Design	866		400
1	8	Inadequate Design	400		20
1	8	Inadequate Design	200		22
3	21	Significant changes in the quantities of work	6334.8		2000
1	6	Change in design request	8116.5		1700
1	6	Change in design request	-9647		
3	32	Owner desire to improve his	-1766		

		financial			
3	32	Owner desire to improve his financial	-225		
1	8	Inadequate Design	8585.8		2704
3	32	Owner desire to improve his financial	-3840		
3	21	Significant changes in the quantities of work	1469.1		466.6
3	21	Significant changes in the quantities of work	2535		1267
3	32	Owner desire to improve his financial	-2040.57		
3	32	Owner desire to improve his financial	-2632.39		
3	32	Owner desire to improve his financial	-1307		
3	32	Owner desire to improve his financial	-2940		
1	1	Design Errors	411.7		259.3
3	32	Owner desire to improve his financial	-1450		
3	32	Owner desire to improve his financial	-14220		
Total		29	-1294.26	0	11160

Case 3: Community Health Center in Deir El-Balah

This project was a community health center in Deir El-Balah and it consisted of adding a new storey and some rehabilitation. The owner of this project was the Ministry of Health and the contract type of this project was a unit price and the duration of this project was 120 days with schedule starting date on 27/01/2003 and a actual starting on 30/01/2003. The delay of this project was 52 days, but only 21 days were causable with finishing date on 22/07/2003. The main reason for the delay was a not enough of contractor crews to perform. The contract value was 185885.99 $ and

the relationship between the contractor, consultant, and owner wasn't a good one and there were some disputes among them.

Percentage of time the project manager spent on the project was not less than 95% and the percentage of change orders initiated by the owner was 2.3% with 75% productivity (Table 2.2) for the project. Table 3 Summaries the result of change orders and their impact on performance.

Table 3: Summary of Community Health Center in Deir El-Balah

Group Number	Factor Number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
4	43	Material non- availability	2100	7	0
4	44	Israeli closure		14	0
9	90	User needs	400		10
1	15	Noncompliance of design with owner’s requirements	3500		300
1	15	Noncompliance of design with owner’s requirements	9000		20
3	21	Significant changes in the quantities of work	1739.5		4025
Total		6	14639.5	0	4355

Case 4: Nasser Hospital - Khan Younis

This project was a community health center in Deir El-Balah and included adding a new building C in Nasser hospital - Khan Younis and doing some rehabilitation. The owner of this project was the Ministry of Health and the contract type of this project was a unit price and the duration of this project was 90 days with schedule starting date on 01/10/2003 and actual starting on 01/10/2003 the delay of this project was 6 non-causable days with finishing date on 06/01/2004. The main reason for the delay was the intensity of change orders. The contract value was 629350 $ and the relationship between the contractor, consultant, and owner was a good one.

The percentage of time the project manager spent on the project was not less than 95% and percentage of change orders initiated by the owner was 3.6% without any productivity (Table 2.2) for the project. Table 4 Summaries the result of change orders and their impact on performance.

Table 4: Summary of Nasser Hospital - Khan Younis

Group Number	Factor Number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
6	53	Suggestions to Initiate more Quality	960	0	30
1	4	Inconsistencies	600	0	37.9
1	4	Inconsistencies	480	0	150
6	53	Suggestions to Initiate more Quality	1800	0	56.4
1	1	Design Errors	805	0	50.7
1	1	Design Errors	2520	0	238
1	1	Design Errors	3570	0	112.4
1	8	Inadequate Design	1900	0	30
6	53	Suggestions to Initiate more Quality	1700	0	10
1	2	Omissions	-1000	0	0
5	48	Safety considerations	2500	0	60
5	48	Safety considerations	150	0	50
1	8	Inadequate Design	600	0	0
10	100	Technology changes	800	0	126
5	48	Safety considerations	600	0	9
1	1	Design Errors.	350	0	5
5	48	Safety considerations	2400	0	0
3	21	Significant changes in the quantities of work	2000	0	200
1	8	Inadequate Design	1100	0	320
1	8	Inadequate Design	800	0	100
3	21	Significant changes in the quantities of work	2743	0	259
3	21	Significant changes in the quantities of	385	0	24

		work			
3	21	Significant changes in the quantities of work	1738	0	218
3	21	Significant changes in the quantities of work	-540	0	0
3	32	Owner desire to improve his financial conditions	-640	0	0
3	32	Owner desire to improve his financial conditions	-1600	0	0
3	21	Significant changes in the quantities of work	4260	0	68
3	21	Significant changes in the quantities of work	2320	0	37
3	21	Significant changes in the quantities of work	3650	0	115
3	21	Significant changes in the quantities of work	3964	0	2000
3	21	Significant changes in the quantities of work	1070	0	101
3	21	Significant changes in the quantities of work	824	0	78
3	21	Significant changes in the quantities of work	3445	0	217
3	21	Significant changes in the quantities of work	1950	0	245
3	21	Significant changes in the quantities of work	1500	0	200
3	21	Significant changes in the quantities of work	1250	0	40
3	21	Significant changes in the quantities of work	1000	0	30
3	21	Significant changes in the quantities of work	350	0	20

3	21	Significant changes in the quantities of work	280	0	20
3	21	Significant changes in the quantities of work	360	0	20
3	21	Significant changes in the quantities of work	275	0	10
3	21	Significant changes in the quantities of work	280	0	10
3	21	Significant changes in the quantities of work	3300	0	50
3	32	Owner desire to improve his financial conditions	-600	0	0
3	32	Owner desire to improve his financial conditions	-225	0	0
3	32	Owner desire to improve his financial conditions	-500	0	0
3	21	Significant changes in the quantities of work	325	0	5
3	21	Significant changes in the quantities of work	150	0	5
3	32	Owner desire to improve his financial conditions	-450	0	0
3	32	Owner desire to improve his financial conditions	-180	0	0
3	21	Significant changes in the quantities of work	-825	0	0
3	21	Significant changes in the quantities of work	-500	0	0
3	21	Significant changes in the quantities of work	-362	0	0
3	48	Safety considerations	6380	0	100
3	21	Significant changes in the quantities of work	-2550	0	0

5	47	Differing Site Conditions	19389	0	2443
Total		56	76851	0	7900.4

Case 5: Al-Shejaa'ea Elementary School for Males

This project was Al-Shejaa'ea Elementary School for Males. The project was a new construction school in Gaza city. The owner of this project was Ministry of Education. The contract type of this project was a unit price and its duration was 300 days with schedule starting date on 02/11/1996 and actual starting on 02/11/1996. The delay of this project was 13 days, only 10 of which were causable, and the finishing date was on 15/09/1997. The main reason for the delay was the plan error but the cause of the non-causable delay was the productivity loss. The contract value was 869278 $ and the relationship between the contractor, consultant, and owner wasn't a good one.

The percentage of time the project manager spent on the project was only 40% and percentage of change orders initiated by the owner was 32.8% with 75% productivity (Table 2.2) for the project. Table 5 Summarizes the result of change orders and their impact on performance.

Table 5 Summary of Al-Shejaa'ea Elementary School for Males

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
3	27	Plan errors	100	10	100
1	4	Design Inconsistencies	2500		472
3	21	Significant changes in the quantities of work	5400		85
7	56	Delays in the Project	0		0
5	49	Differing subsurface conditions	6420		202
4	39	Uncovering disclosed existing conditions	3400		428.2
5	49	Differing subsurface conditions	5104		80.4
1	1	Errors	500		30
1	8	Inadequate Design	150		15

9	90	User needs.	1040		32.7
6	53	Suggestions to Initiate more Quality	9855		62
6	53	Suggestions to Initiate more Quality	2080		13
3	31	Change in the owner's requirements	1200		75
1	8	Inadequate Design	350		5
1	8	Inadequate Design	3000		378
1	1	Errors	50		50
1	8	Inadequate Design	1387.3		174.7
4	39	Uncovering disclosed existing conditions	10500		1984
6	53	Suggestions to Initiate more Quality	15520		1466.6
9	90	User needs	500		315
1	8	Inadequate Design	2880		362.8
5	49	Differing subsurface conditions	9735.1		613
5	48	Safety considerations	150		9
1	8	Inadequate Design	522.7		6.6
1	8	Inadequate Design	3981.6		501
1	8	Inadequate Design	2100		132
4	39	Uncovering disclosed existing conditions	2660		335.2
1	8	Inadequate Design	2600		327
6	53	Suggestions to Initiate more Quality	680		10.7
9	90	User needs	100		7
Total		30	94465.7	10	8272.9

Case 6: Sheikh Radwan School

This project was a new construction for Sheikh Radwan School in the City of Gaza. The project owner was the Ministry of Education. The contract type of this project was a unit price and the duration of this project was 300 days with schedule starting date on 02/11/1996 and actual starting on 02/11/1996 and there was no delay on this project so the finish date was on15/09/1997. The contract value was 869278 $ and the relationship between the contractor, consultant, and owner fluctuated between good and bad.

The percentage of time the project manager spent on the project not less than 95% and the percentage of change orders initiated by the owner was 71.5% with 75% productivity (Table 2.2) for the project. Table 6 summarizes the result of change orders and their impact on performance.

Table 6: Summary of Sheikh Redwan School

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
1	8	Inadequate Design	3000		600
1	1	Errors	150		150
5	48	Safety considerations	1200		240
1	8	Inadequate Design	1387.3		174.7
1	1	Errors	500		30
1	8	Inadequate Design	150		15
9	90	User needs	1040		239.2
6	53	Suggestions to Initiate more Quality	9855		62
6	53	Suggestions to Initiate more Quality	2080		13
3	31	Change in the owner's requirements	1200		75
1	8	Inadequate Design	350		5
1	8	Inadequate Design	522.72		39.6
1	8	Inadequate Design	3981.6		426.6
1	8	Inadequate Design	2100		60
6	53	Suggestions to Initiate more Quality	23280		3638
9	90	User needs	100		7
Total		16	50896.62	0	5775.1

Case 7: Al-Karmel Secondary School

This project was comprised adding a new classroom with rehabilitation in Al-Karmel Secondary School in the City of Gaza. The owner of this project was the Ministry of Education. The project contract type was a unit price and its duration was 6 months with schedule starting date on 24/11/2002 and actual starting on 24/11/2002. The delay of this project was 87 days, but the causable delay was 90 days. The finish

date was on 21/08/2003; the main reason for the delay was differing site conditions and Israeli closures. The contract value was $209950 and the relationship between the contractor, consultant, and owner was a good one.

The percentage of time the project manager spent on the project was not less than 95% and the percentage of change orders initiated by the owner was 13.7% with 75% productivity (Table 2.2) for the project. Table 7 summarizes the result of change orders and their impact on performance.

Table 7: Summary of Al-Karmel Secondary School

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
5	47	Differing Site Conditions	27321.2	45	5163.7
5	47	Differing Site Conditions	13760		2167.2
5	48	Safety considerations	400		52
5	47	Differing Site Conditions	210		15
6	53	Suggestions to Initiate more Quality	7600		957.6
5	47	Differing Site Conditions	1700		214.2
5	49	Differing subsurface conditions	3701.2		116.5
4	44	Israeli closure		45	0
5	49	Differing subsurface conditions	-746.88		0
Total		9	53945.52	90	8686.2

Case 8: Khalid Bin Al Waleed School

This was a new construction for Khalid Bin Al Waleed School in Al-Nusirat Camp. The owner of this project was the Ministry of Education and the contract type was a unit price with duration of 300 days. The schedule starting date was on 08/06/1997 and actual starting on 08/07/1997. The delay on this project was 7 days with 10 days of causable delay. The finishing date was 11/05/1998 and the main reason for the delay was Israeli closures. The contract value was $ 716573 and the relationship between the contractor, consultant, and owner wasn't a good one.

The percentage of time the project manager spent on the project was not less than 70% and the percentage of change orders initiated by the owner was 49.8% with 75% productivity (Table 2.2) for the project. Table 8 summarizes the result of change orders and their impact on performance.

Table 8: Summary Khalid Bin Al Waleed School

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
9	87	A prevalent practice on this project and/or district	1000		63
1	4	Design Inconsistencies	150		94.5
4	44	Israeli closure	0	10	0
6	53	Suggestions to Initiate more Quality	3400		428.5
6	53	Suggestions to Initiate more Quality	5780		
6	53	Suggestions to Initiate more Quality	4250		2677
6	53	Suggestions to Initiate more Quality	400		910.3
4	43	Material non- availability	310		0
6	53	Suggestions to Initiate more Quality	40256		7400
6	53	Suggestions to Initiate more Quality	11180		2150
5	49	Differing subsurface conditions	43360		6829
6	53	Suggestions to Initiate more Quality	1400		262.5
6	53	Suggestions to Initiate more Quality	300		14
1	5	Design Impossibilities	550		20
9	96	96Socio-cultural factors	700		50

1	8	Inadequate Design	1532.5		482.7
1	8	Inadequate Design	-264		0
3	32	Owner desire to improve his financial	-1160		0
6	53	Suggestions to Initiate more Quality	500		0
1	8	Inadequate Design	466		10
1	8	Inadequate Design	2580		325
1	8	Inadequate Design	500		20
5	49	Differing subsurface conditions	11108		699.8
9	90	User needs	413.3		13.2
1	1	Design Errors	400		10
1	8	Inadequate Design	750		21
9	96	Socio-cultural factors	250		40
6	53	Suggestions to Initiate more Quality	150		5
1	8	Inadequate Design	2790		87
Total		29	133051.8	10	22612.5

Case 9: Nusairat Girls Basic School

This project was a new construction of Nusairat Elementary Girl School in Al-Nusairat camp. The owner of this project was the Ministry of Education. This project contract type was a unit price and the duration of this project was 300 days with schedule starting date 08/01/1997 and actual starting 08/01/1997 and the delay of this project was 13 days with 12 days causable delay. The finishing date was the 17/11/1997 and the main reason for the delay was Israeli closure and the extreme whether condition. The contract value was $856439 and the relationship between the contractor, consultant, and owner was rather a good one.

The percentage of time the project manager spent on the project was not less than 85% and the percentage of change orders initiated by the owner was 24.9% with 75% productivity (Table 2.2) for the project. Table 9 summarizes the result of change orders and their impact on performance.

Table 9: Summary of Nusairat Girls' Basic School

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
1	8	Inadequate Design	6000		94.5
1	8	Inadequate Design.	1050		66.1
6	52	Suggestions to Initiate more economical construction	-6930		0
3	21	Significant changes in the quantities of work	6064		1213
6	52	Suggestions to Initiate more economical construction	-755.1		0
3	21	Significant changes in the quantities of work	-11448		0
3	21	Significant changes in the quantities of work	8200		2460
3	21	Significant changes in the quantities of work	2124		486
3	21	Significant changes in the quantities of work	4143		1726
3	21	Significant changes in the quantities of work	243		67.5
3	21	Significant changes in the quantities of work	730		110
5	47	Differing Site Conditions	5900		929.2
3	21	Significant changes in the quantities of work	8127		1024
6	53	Suggestions to Initiate more Quality	20225		4334
1	8	Inadequate Design	3150		300
1	8	Inadequate Design	3863.7		414
4	44	Israeli closure	0	8	0
4	42	Extreme whether condition	0	4	0

1	8	Inadequate Design	859.6		215
6	53	Suggestions to Initiate more Quality	1785		112.5
6	53	Suggestions to Initiate more Quality	832		52.4
6	53	Suggestions to Initiate more Quality	74		5
1	8	Inadequate Design	471.2		157
9	87	A prevalent practice on this project and/or district	5296		834.1
10	98	Mechanical and electrical provision	1010		63
6	53	Suggestions to Initiate more Quality	2340		230
1	8	Inadequate Design	84		6
1	8	Inadequate Design	150		5
5	48	Safety considerations	50000		7875
6	53	Suggestions to Initiate more Quality	380		23.8
9	96	Socio-cultural factors	200		12.5
5	48	Safety considerations	1056		66.5
6	53	Suggestions to Initiate more Quality	16745		0
6	53	Suggestions to Initiate more Quality	400		12
9	90	User needs	900		141.7
6	52	Suggestions to Initiate more economical construction	-2400		0
Total		36	130869.4	12	23035.8

Case 10: Al-Qezan School

This project was a new construction of Al-Qezan School in Khan Younis. The owner of this project was the Ministry of Education and contract type was a unit price with 300 days' duration. Schedule starting date was the 25/01/1997 and actual starting

the 25/01/1997. The delay on this project was 19 days with 12 days causable delay so the finishing date was the 10/12/1997. The main reason for the delay was Israeli closures and the extreme weather conditions and the non-causable delay was because the contractor did not use enough labor. The contract value was $735280.5 and the relationship between the contractor, consultant, and owner was a rather good one.

The percentage of time the project manager spent on the project was not less than 90% and percentage of change orders initiated by the owner was 24.9% with 75% productivity (Table 2.2) for the project. Table 4.10 summarizes the result of change orders and their impact on performance.

Table 4.10 Summary of Kan Younis School

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
1	1	Design Errors	150		2
1	1	Design Errors	900		14.1
1	8	Inadequate Design	5085		320
9	87	A prevalent practice on this project and/or district	5735		903.2
4	44	Israeli closure	0	8	0
4	42	Extreme whether condition	0	4	0
1	8	Inadequate Design	1050		66
6	53	Suggestions to Initiate more Quality	475		47.5
9	96	Socio-cultural factors	200		5
2	18	Specified item became unavailable	1200		0
6	53	Suggestions to Initiate more Quality	16745		0
5	48	Safety considerations	2250		450
1	8	Inadequate Design	2800		400
6	53	Suggestions to Initiate more Quality	17771		4101
6	53	Suggestions to Initiate more Quality	2340		156
Total		15	56701	12	6464.8

Case 11: Constructing Housing Building – Building 2/2005 - Rafah

This project comprised constructing a new residential building for the Engineering Institute in Rafah City. The owner of this project was the Ministry of Public Works and Housing. The contract type of this project was a unit price and the duration of this project was 12 months with schedule starting date the 22/04/2006 and actual starting date the 22/04/2006. The delay of this project was 53 days with 60 days causable delay and the finishing date was the 14/06/2007. The main reason for the delay was the Israeli closures. The contract value was $706965.49 and the relationship between the contractor, consultant, and owner was a good one.

The percentage of time the project manager spent on the project was only 95% and the percentage of change orders initiated by the owner was 23.6% with 75% productivity (Table 2.2) for the project. Table 4.11 summarizes the results of change orders and their impact on performance.

Table 4.11 Summary of Building 2/2005 - Rafah

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
3	27	plan error	25665		4042
1	4	Design Inconsistencies	366	1	122
9	83	Utility Companies	123.8		0
6	52	Suggestions to Initiate more economical construction	-4000		0
1	4	Design Inconsistencies	0		0
1	1	Design Errors	100		6
3	32	Owner desire to improve his financial conditions	-3400		0
4	44	Israeli closure	0	58	0
6	53	Suggestions to Initiate more Quality	4200		900
1	5	Design Impossibilities	600		0
5	48	Safety considerations	650		300
1	8	Inadequate Design	537.5		51.6

6	53	Suggestions to Initiate more Quality	3500		551.25
5	48	Safety considerations	10000		1575
1	8	Inadequate Design	476		102
1	8	Inadequate Design	1908		360
5	48	Safety considerations	3177		200
9	90	User needs	195		12
1	8	Inadequate Design	400		34
1	8	Inadequate Design	1240		116.3
10	100	Technology changes	1075		140
10	100	Technology changes	1208		100
10	100	Technology changes	600		38
1	8	Inadequate Design	1419.5		250
1	8	Inadequate Design	405		70
3	32	Owner desire to improve his financial conditions	-2400		0
3	32	Owner desire to improve his financial conditions	-600		0
1	8	Inadequate Design	3570		255
1	8	Inadequate Design	133.9		10.3
1	8	Inadequate Design	1500		100
1	8	Inadequate Design	600		10
Total		31	53249.7	59	9345.45

Case 12: Constructing Housing Building – Building 3/2002 - Gaza

This project comprised constructing a new residential building for the Palestinian Control and Investigation Board in Gaza City. The owner of this project was the Ministry of Public Works and Housing. The contract type of this project was a unit price and its duration was 12 months with schedule starting date the 23/04/2003 and actual starting date 23/04/2003. The delay of this project was 50 days of causable delays and the main reason for the delay was Israeli closures and differing subsurface conditions. The contract value was 477334 $ and the relationship between the contractor, consultant, and owner was a good one.

The percentage of time the project manager spent on the project was only 95% and the percentage of change orders initiated by the owner was 14.4% with 75% productivity (Table 2.2) for the project. Table 4.12 summarizes the results of change orders and their impact on performance.

Table 12: Summary of building 3/2002 - Gaza

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
5	49	Differing subsurface conditions	4679	10	294.8
9	91	Review of the project by the proper governmental agency	0	1	0
1	8	Inadequate Design	400	0	25
9	90	User needs	1400	0	175
8	71	Honest wrong beliefs of consultant	14875	0	1275
6	54	Value Engineering	-18000	0	0
1	8	Inadequate Design	6743	0	1062
9	90	User needs	300	0	20
9	90	User needs	2500	0	5
6	53	Suggestions to Initiate more Quality	3455.2	0	544
9	90	User needs	800	0	150
1	8	Inadequate Design	486	0	50
6	53	Suggestions to Initiate more Quality	300	0	40
4	44	Israeli closure	0	24	0
6	53	Suggestions to Initiate more Quality	254	0	40
6	53	Suggestions to Initiate more Quality	1680	0	112
5	48	Safety considerations	2185	0	350
1	8	Inadequate Design	736	0	63
1	8	Inadequate Design	253.5	0	31
5	48	Safety considerations	81	1	25
5	48	Safety considerations	440	14	50
Total		21	23567.7	50	4311.8

Case 13: Constructing Housing Building – Building 1/2002 - Rafah

This project entailed constructing a new residential building in Rafah city. The owner of this project was the Ministry of Public Works and Housing. The contract type of this project was a unit price and its duration was 8 months with schedule starting date in 23/04/2003, actual starting date in 23/04/2003, and finishing date in 04/03/2003. The contract value was 276879.5 $ and the relationship between the contractor, consultant, and owner was a good one.

The percentage of time the project manager spent on the project was only 95% and the percentage of change orders initiated by the owner was 0% with 75% productivity (Table 2.2) for the project. Table 4.17 summarizes the results of change orders and their impact on performance.

Table 4.13 Summary of building 1/2002 - Rafah

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in Time (days)	Labor cost($)
4	41	Strikes	3835	0	966.4
5	48	Safety considerations	292.4	0	18.4
Total		2	4127.4	0	984.8

Case 14: Constructing Housing Building – Building 1/2003 - Gaza

This project entailed constructing a new residential building for the Palestinian Control and Investigation Board in Gaza City. The owner of this project was the Ministry of Public Works and Housing. The projects' contract type was a unit price and its duration was 12 months with schedule starting date in 14/12/2003, actual starting in 13/08/2004, and the project's delay was 37 days, but the causable delay was only 26 days. The main reason for the delay was Israeli closures and differing subsurface conditions. The contract value was 587528 $ and the relationship between the contractor, consultant, and owner was a bad one as the contractor strategy was claimer.

The percentage of time the project manager spent on the project was only 95% and the percentage of change orders initiated by the owner was 8% with 75% productivity (Table 2.2) for the project. Table 4.18 summarizes the results of change orders and their impact on performance.

Table 4.14 Summary of building 1/2003 - Gaza

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
5	49	Differing subsurface conditions	7365	4	928
5	48	Safety considerations	2185		276
9	96	Socio-cultural factors	1300		0
9	90	User needs	1200		400
9	90	User needs	1500		415
1	8	Inadequate Design	580		15
1	8	Inadequate Design	1082		137
1	8	Inadequate Design	1200		250
1	4	Design Inconsistencies	147		18.5
6	54	Value Engineering	-18000		0
9	90	User needs	47.6		7.5
9	90	User needs	297		46.8
9	90	User needs	117		18.5
9	90	User needs	325		51.2
9	90	User needs	245		38.6
9	90	User needs	47.6		7.5
9	90	User needs	297		46.8
9	90	User needs	89		14
9	90	User needs	108.5		17.1
4	44	Israeli closure		11	0
4	44	Israeli closure		11	0
9	95	Change in economic conditions	2200		75
9	95	Change in economic conditions	9000		1984
9	95	Change in economic conditions	2800		840
1	8	Inadequate Design	170		20
3	21	Significant changes in the quantities of work	1952		369
3	21	Significant changes in the quantities of work	97.6		35

3	21	Significant changes in the quantities of work	169		21.3
6	53	Suggestions to Initiate more Quality	100		0
3	21	Significant changes in the quantities of work	334		10
5	48	Safety considerations	78		10
Total		31	17033.3	26	6051.8

Case 15: Constructing Housing Building – Building 1/2005 - Gaza

This project comprised constructing a new residential building for Personnel Department of the Palestinian Authority (Diwan Almothafeen) in Gaza City. The owner of this project was the Ministry of Public Works and Housing. The project's contract type was a unit price and its duration was 8 months with schedule starting date in 20/04/2005, actual starting in 20/04/2005, and the delay of this project was 22 days and it was non-causable delay. The reason for the delay was that the contractor company was a novice one in the field without any experience. The contract value was 564475 $ and the relationship between the contractor, consultant, and owner was a bad one.

The percent of time the project manager spent on the project was only 95% and the percentage of change orders initiated by the owner was 92% with 75% productivity (Table 2.2) for the project. Table 15 summarizes the results of change orders and their impact on performance.

Table 4.15: Summary of Building 1/2005 - Gaza

Group Number	Factor number	Factors causing change	Total Cost($)	Extension in time (days)	Labor cost($)
1	1	Design Errors	1100	0	207
9	90	User needs	3000	0	0
9	90	User needs	900	0	141
6	54	Value Engineering.	-18000	0	0
1	8	Inadequate Design	1060	0	250
5	48	Safety considerations	660	0	40
9	90	User needs	600	0	75.6

5	48	Safety considerations	360	0	22.7
9	90	User needs	440	0	55
9	95	Change in economic conditions	38880	0	10800
5	48	Safety considerations	1400	0	200
9	95	Change in economic conditions	7392	0	1120
9	90	User needs	340	0	45
9	95	Change in economic conditions	700	0	100
6	53	Suggestions to Initiate more Quality	200	0	50
9	95	Change in economic conditions	3500	0	500
Total		16	42532	0	13606.3